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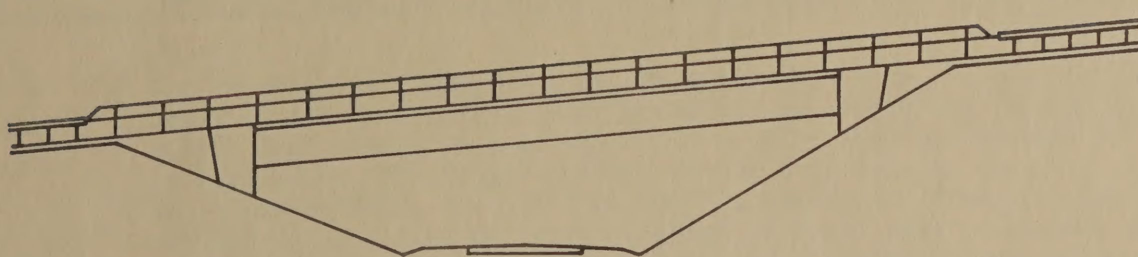

# FIELD SURVEY MANUAL FOR BRIDGE DECK OVERLAY PROJECTS

materials bureau technical services subdivision

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The Federal-Aid Highway Program Manual (Vol. 6, Ch. 7, Sec. 2, Subsec. 7) requires that a detailed field appraisal be made of any bridge deck to define the inadequacies of the existing deck when restoration of the deck is warranted. The Manual further states that such an appraisal should, where appropriate, include delamination detection, determination of reinforcing steel corrosion, determination of areas with inadequate concrete cover, and determination of the extent of chloride contamination. The Materials Bureau has been given the responsibility for developing suitable field procedures, acquiring the necessary equipment, and training Regional personnel to perform bridge deck surveys.

Since the issuance of a draft field manual, a pilct training program was conducted and the subsequent reviews have resulted in the final version entitled "Field Survey Manual for Bridge Deck Overlay Projects", copies of which accompany this instruction. This manual is a supplement to, not a replacement of, the Bridge Deck Evaluation Procedure Manual, issued by the Structures Subdivision.

The data required by FHWA is used to specify the areas of the deck requireing various types of repair in the design of the reconstruction project. Our experience to date has shown these procedures to be an accurate and valuable predictor of the repairs necessary to restore a deteriorated deck. In addition this data represents a valuable source of historic information for the prediction of bridge deck life, evaluation of deck design alternatives, and forecasting future maintenance needs. In order to provide uniformity in the collection and presentation of this data, it will be entered in the computer for analysis, mapping and storage. Computer storage of the data will be particularly useful in the analysis of the cost effectiveness of experimental reconstruction projects which require periodic resurveys of the deck condition.

The attached field manual presents the current state of the art of the measurement procedures used to determine the surface condition of a bridge deck. It is specific and contains detailed instructions to be followed by the survey crews in the field.

The manual makes reference to a computer mapping program for the preparation of concrete removal maps which will be available through the Materials Bureau. The program will produce four maps for each slab-span surveyed showing the depth of cover, corrosion potential, and the two classes of concrete removal other than scarification. The 11" x 17" original and four 8½" x 11" copies of each map will be returned to the Region for use in the "Deck Evaluation Report - Monolithic Deck Reconstruction Projects" required by the Structures Subdivision. In addition to the savings to be realized in the man-hours required to produce such maps, use of the computer produced maps will standardize the format of the maps both within and between Regions.

Spall, delamination and crack data will have to be added to the computer maps by hand in the Region. The resultant maps will be included in the design report and eventually in the contract plans after transfer to a reproducible, such as Mylar.

The Structures Subdivision will issue a new procedure manual for the preparation of deck evaluation reports fully incorporating the techniques described in the Field Survey Manual for Bridge Deck Overlay Projects. Until that time the methods described in the subject manual should be utilized as a part of the bridge reconstruction evaluations as noted above.

Any questions regarding the content of the manual, conduct of the survey, or the computer output should be referred to the Field Services Sections of the Materials Bureau. Questions regarding the use of this data in the design of the deck reconstruction should be referred to the Structures Design and Construction Subdivision.

# FIELD SURVEY MANUAL FOR BRIDGE DECK OVERLAY PROJECTS

July, 1977

MATERIALS BUREAU, TECHNICAL SERVICES SUBDIVISION
New York State Department of Transportation
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# PREFACE

Many monolithic slabs exhibit surface distress such as delamination and spalling. Some factors which contribute to these conditions are deficient concrete cover over top reinforcing steel, infiltration of deicing chemicals, and poor quality concrete. The result of a combination of these factors is usually corrosion of the top reinforcing steel. The corrosion products cause severe tensile stresses in the concrete which lead to delamination and spalling. However, the spalls and delaminations that are visually evident represent only the "tip of the iceberg." Many areas that appear to be in good condition possess some of the factors noted above and represent future sites of concrete deterioration if left untreated. Therefore any evaluation of the slab must include procedures to detect these conditions. The procedures and techniques described in this manual will provide input to the design process so that an accurate estimate of concrete removal work can be computed and shown on the contract plans.

TABLE OF CONTENTS

# INTRODUCTION

New methods for concrete bridge deck evaluation have been developed that when combined with traditional evaluation techniques, can provide a more comprehensive description of the condition of a deck. This information can be used to more accurately determine the type of repair necessary and the contract quantities required.

The methods of evaluation and a brief description of their purpose are shown below:

| Evaluation Technique | Purpose |
|---|---|
| Reinforcing Steel Corrosion Potential | Determine areas of actively corroding reinforcing steel. Corrosion of reinforcing steel causes delaminations and spalls in the concrete deck. Determines extent of concrete removal required. |
| Depth of Concrete Cover over Reinforcing Steel | Determine depth of concrete cover. Inadequate cover contributes to early chloride penetration. Determines final grade of repair. |
| Chloride Analysis | Determine depth of chloride penetration and quantities of chloride ion present in the concrete. High chloride ion concentration (1-1.3 lb./cu.yd.) induces reinforcing steel corrosion if moisture and oxygen are present. |
| Delamination Detection - Chain Drag | Determine delaminated areas not visually evident. |
| Visual Inspection | Locate cracks, spalls, patches and other obvious signs of distress. |
| Data Verification Calibration Cores | Concrete cores are taken to investigate areas where structural integrity of deck is suspect or where depth of deterioration is unknown. Used in any questionable areas not adequately defined by other techniques. Also used to verify the accuracy of pachometer and potential data. |

The following chapters describe how these evaluation techniques are combined in a bridge deck condition survey. Chapters I-III give specific details of how the survey is conducted including employee safety and traffic maintenance; establishing a coordinate reference system on the deck; and recording data. Chapters IV-VIII describe the procedures used for each of the evaluation techniques noted above. Chapter IX outlines the procedure for processing samples and field data, and how the data is input to the design process. Included at the back of the manual are Appendix A which explains the corrosion process and the theory behind the corrosion potential measurement, Appendix B which lists the equipment necessary to conduct a deck condition survey, and Appendix C which shows sample computer maps.

Although this manual is intended to cover all the possible problems that may arise in the performance of a survey, there undoubtedly will occur situations not covered by this text. In those cases, or when problems with the equipment or data occur, contact the Materials Bureau for assistance.

## I EMPLOYEE SAFETY AND TRAFFIC MAINTENANCE

Bridge deck surveys are usually performed on structures which are in service. In rare instances it is possible to shut down the entire structure while the survey is being performed, but in most cases traffic must be maintained during the survey. It is imperative that the survey crew provide for the safe operation of traffic on the structure during the survey, and that they take all necessary safety precautions to protect themselves from injury. The following instructions should help the survey crew complete their work with little traffic disruption and an adequate level of personal safety.

1. Traffic protection should be provided in accordance with Appendix 7 of the Manual of Uniform Traffic Control Devices (MUTCD) Figures MC-5A, 7A, 10, 11, or 12 for stationary work of short duration. A copy of that portion of the MUTCD is included in the Appendix of the Highway Maintenance Subdivision's "Safety Manual." Specifically, signs, vehicles, cones, flagmen, etc. should be placed in conformance to the MUTCD. However, these are minimum requirements; each situation may require judgement as to what constitutes proper traffic control. For example, if for a given work site more equipment is needed to safely control traffic (such as reduced speed signs, cones, trucks, etc.), be certain to arrange for the necessary equipment.

2. All workers at the survey site must wear safety vests and hard hats. This is required in order to amplify the workers' visibility to the moving motorists.

3. A portable rotating flashing amber warning lamp, powered from the battery of the state vehicle should be placed in operation on top of the survey vehicle. The vehicle should then be parked in the protected lane between oncoming traffic and the work crew (see Figure 1-1). This should be done in addition to precautions normally observed by the regular traffic protection crew. After each use of the lamp, be certain to remove it from the top of the vehicle before moving on.

4. Excessive noise levels are often encountered at work sites. This makes it difficult to hear warnings from flagmen. It is therefore recommended that all flagmen and the survey crew agree on how to take precautions to ensure that workers can hear the flagmen's warnings. For example, such warnings are particularly useful at the approach of wide loads.

5. It is imperative that all flagmen constantly be aware of and properly control traffic. Therefore, survey crews should insist that flagmen

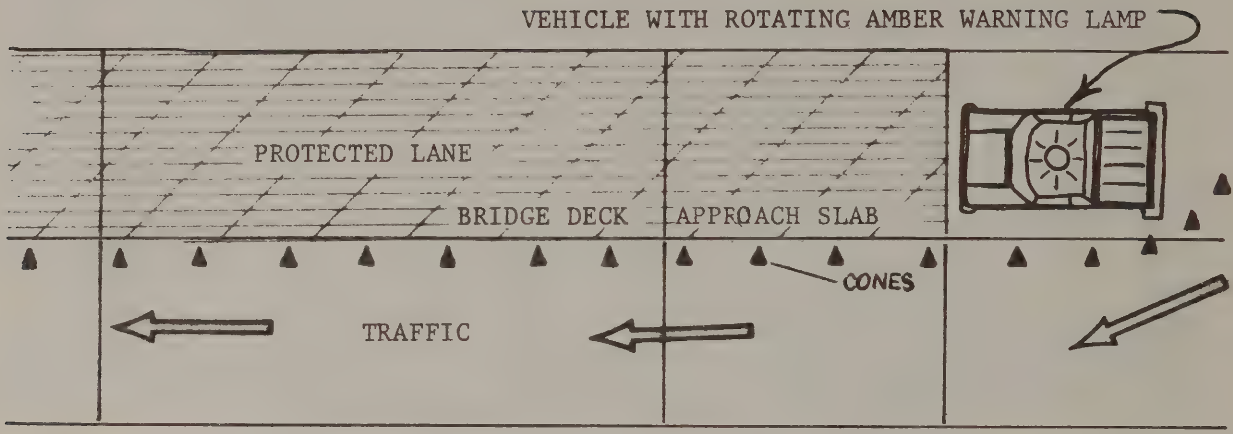



Figure 1-1. Location of vehicle with warning lamp.

are constantly at their proper locations performing their duties. If flagmen do not properly control traffic at all times, speak to the flagman and direct him to do it right. If this fails, stop work until the situation is corrected.

6. While taking readings, always stay as far as possible from the traffic lane; overhanging loads and large truck mirrors may extend over cones into the work area. Always face and be aware of oncoming traffic. This will increase your reaction time if a vehicle runs through the cones. All equipment and personnel not required to be in the roadway should be stationed in safe areas at edges. For example, enough wire is available in each survey kit to usually allow the voltmeter to be located on the sidewalk while corrosion potentials are measured. Constantly be aware of where you are working, don't forget and back into a traffic lane. Plan your movements before you act.

7. If unsafe conditions exist in the work area, work should be discontinued until safe conditions are established.

Following the above procedures should greatly reduce potential hazards to work crews.

# II GRID LAYOUT

The deck condition survey must be performed in such a manner that people not involved in the survey can relate the data to the structure. For this reason several conventions of the Bridge Inventory and Inspection System have been adopted so that a uniform set of field procedures are followed by each survey crew. The following instructions explain how the survey crew will lay out a coordinate system on the bridge to which all data will be referenced.

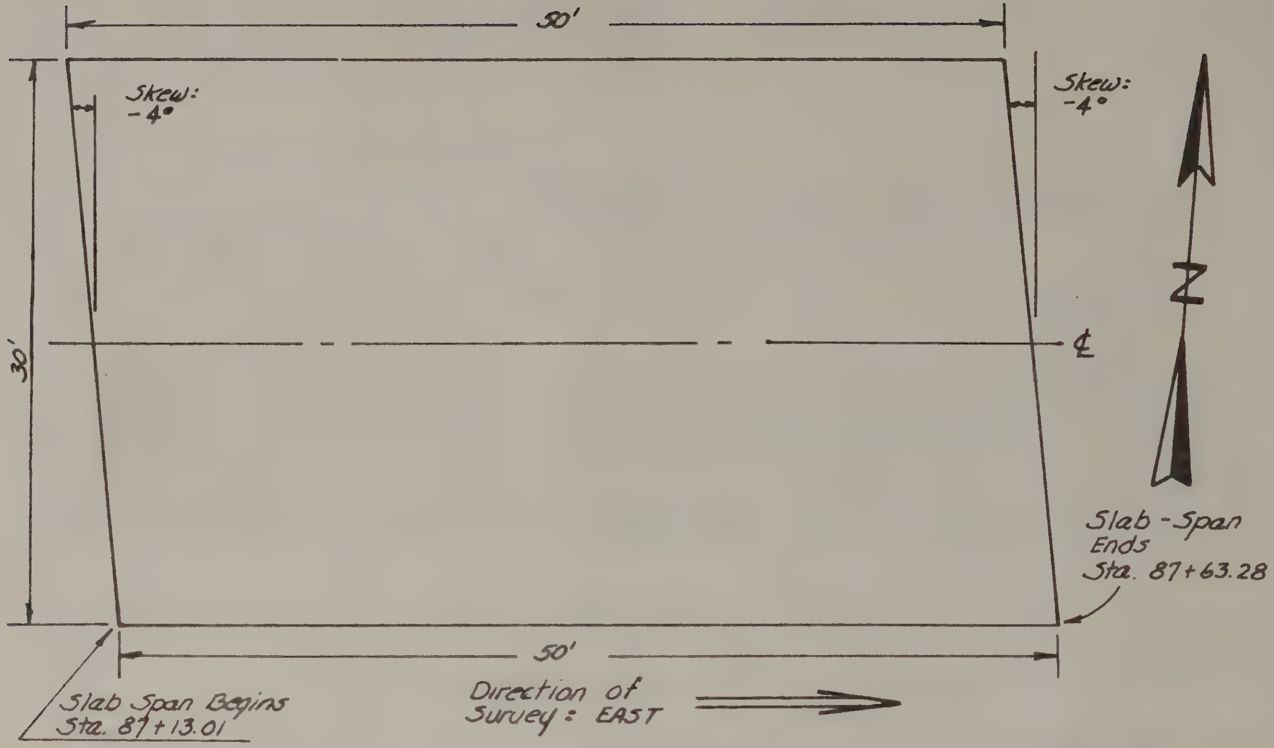
Prior to going out in the field the survey crew should prepare an accurate (1"=10') drawing of each slab-span based on the record plans for the structure. The drawing should include the following information:

1. Bridge Identification Number
2. Slab-span number
3. Skew angle of transverse joint at each end (skew angle shown on plans may not be the skew angle of the transverse joints)
4. Centerline radius
5. Length of slab-span along each curb
6. Width of slab-span (perpendicular to the centerline)
7. Station locations of the beginning and ending joints
8. Direction of survey
9. North arrow

The drawing is used to determine a suitable grid layout for the slab-span. A copy of the drawing is used to record the location of cracks, delaminations, spalls, and patches. A copy of the drawing is then forwarded to the Materials Bureau along with the completed bridge deck condition survey forms as described in Chapter IX.

Examples of suitable drawings for a tangent and curved slab-span are shown in Figure 2-1. A copy of this drawing should be used to determine an appropriate grid layout before going out in the field. This is useful to make certain that the survey is performed in the right direction and the grid is laid out properly. In the drawings shown, the upper left hand corner is used as the reference point for each data grid.

The first choice facing the survey crew is to determine on which end of the structure to begin. The survey will always be started at the end of the structure with the lower stationing according to the record plans, and will proceed in the direction of increasing stations (see Figure 2-2). In this manner the concrete removal maps by the computer will always be laid out with the stationing increasing from left to right across the page. Once the beginning end of the structure has been determined, the survey crew can begin to lay out a grid on each slab-span of the deck. A slab-span is defined as that



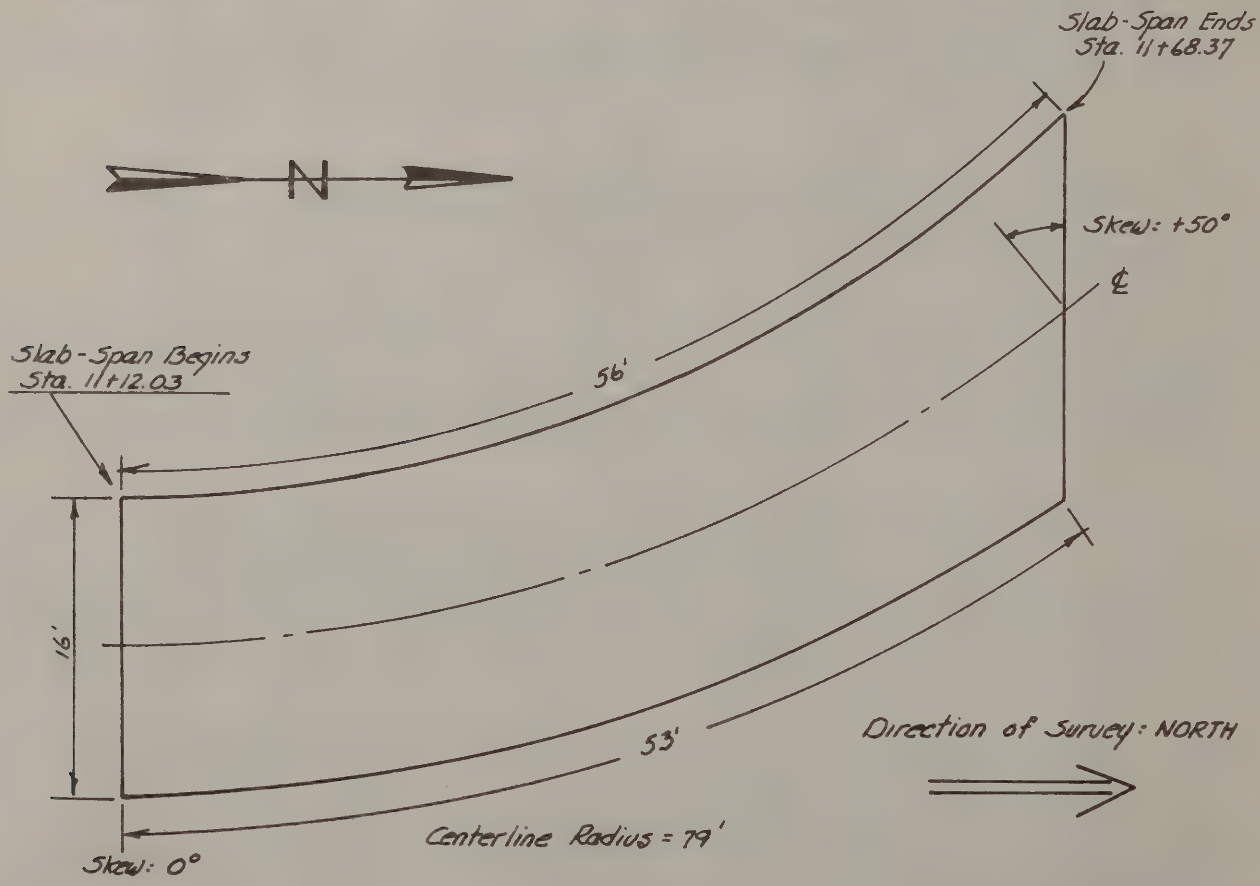




Figure 2-1 Typical 1"=10' drawings.

portion of the bridge deck contained between two successive transverse joints. Approach slabs are surveyed in the direction of increasing stationing as well.

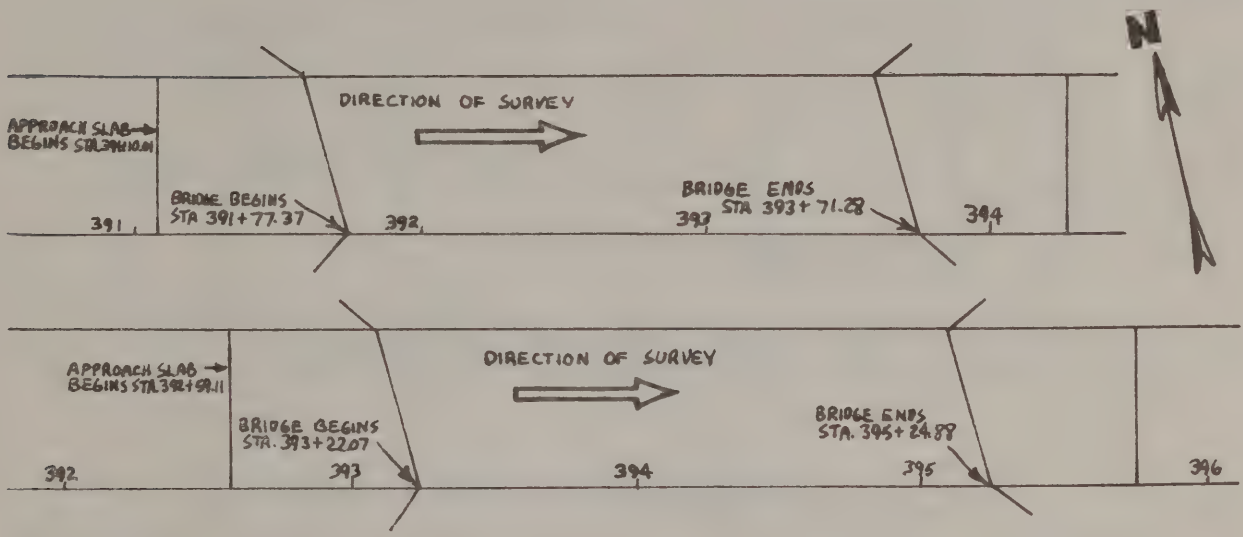



Figure 2-2 Direction of survey.

All decks will be surveyed using a two dimensional grid, however there are some differences in the methods used to lay out a grid on a tangent (straight) structure and on a curved structure. For the purposes of the bridge deck condition survey, a slab-span with a centerline radius less than or equal to 1910 feet, i.e. a degree of curvature greater than or equal to 3 degrees is considered a curved slab-span. Slab-spans with a centerline radius greater than 1910 feet are considered to be tangent slab-spans and a rectangular grid should be used as outlined in the following instructions. The procedures for laying out a grid on a curved slab-span are given in Section B of this chapter. Approach slabs are surveyed using the same procedures given for slab-spans.

## A. Tangent Slab-spans: Radius Greater Than 1910 Feet

Each measurement made on the slab-span at a particular position has a transverse and longitudinal location associated with it. In order to identify those locations for future reference it is necessary to define a particular reference point on each slab-span from which the longitudinal and transverse locations are measured. The reference point for all measurements shall be the left corner of the slab-span or approach slab at the transverse joint with the lower stationing according to the record plans when looking in the direction of survey. (See Figure 2-3).

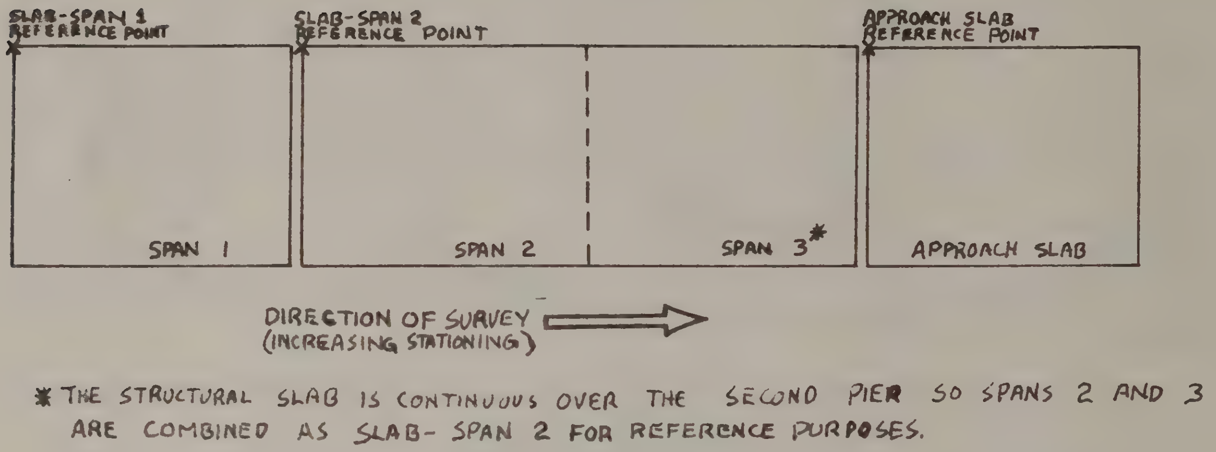



Figure 2-3. Determination of reference point.

The transverse location is defined as the distance to the nearest foot, perpendicular to the pavement centerline from the face of the left curb or if none, the edge of the fascia on the left side to the point in question (see Figure 2-4).

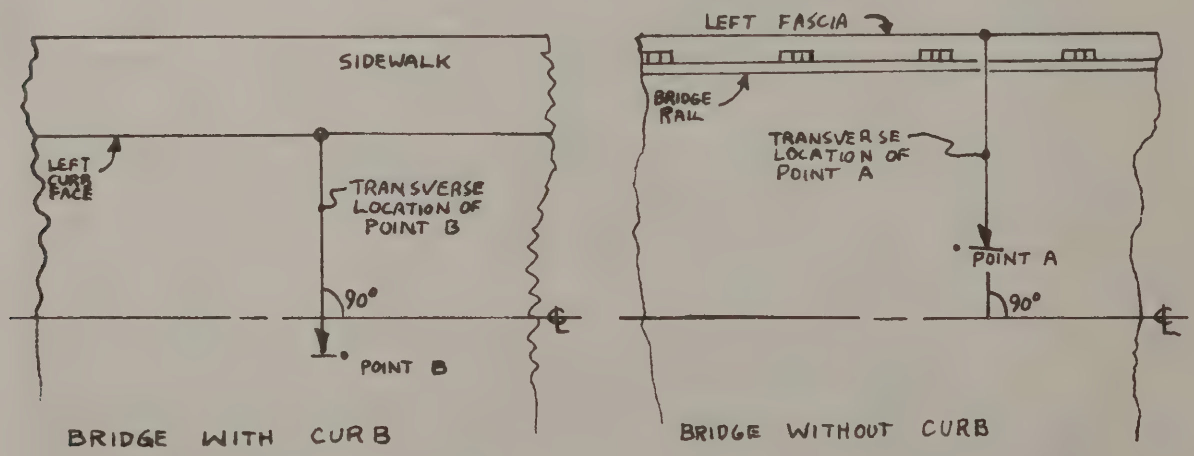



Figure 2-4. Determination of transverse location.

The longitudinal location is defined as the distance to the nearest foot, as measured along the curb from the edge of the transverse joint with the lower stationing, to the point in question (see Figure 2-5). On curved structures this is measured along the curb as an arc, not a chord.

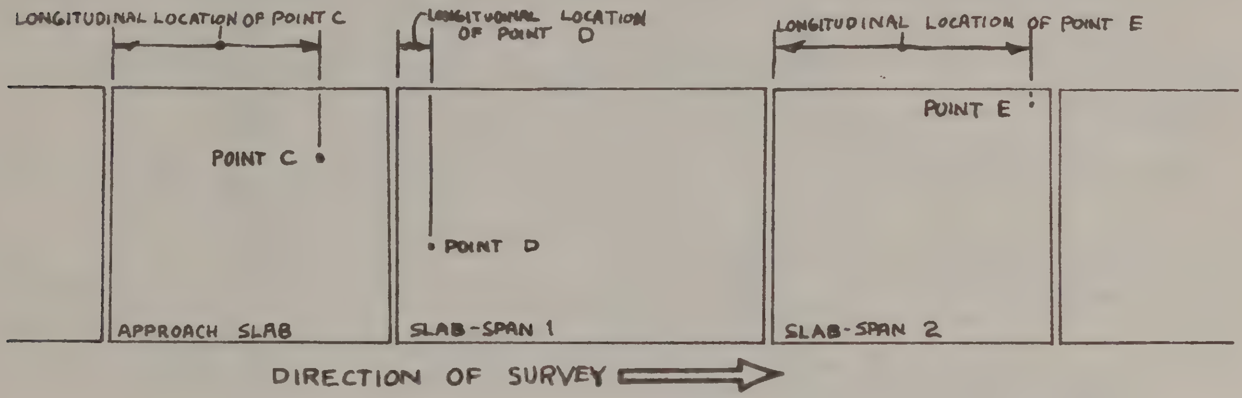



Figure 2-5. Determination of longitudinal location.

The survey crew should begin laying out the grid by marking the appropriate intervals along the left curb or left fascia from the edge of the transverse joint. A cloth tape is sufficiently accurate to determine these locations on the deck. Table 2-1 gives grid interval sizes for the most common measurements made during a bridge deck condition survey. Since the five foot by five foot grid is common to all measurements, this should be laid out on the deck first. Additional points may then be located as needed relative to the existing grid. Smaller intervals may be used if there is reason to believe more accurate data is required, but the suggested sizes in the table are the minimum necessary for analysis of the deck condition. The intervals may be conveniently marked with a spot of paint.

After the longitudinal intervals have been laid out along the left hand side of the deck, the crew should lay out a transverse line at each longitudinal interval by approximating a line perpendicular to the centerline of the deck. The line should be marked with paint or crayon at the appropriate intervals. An example of a tangent deck with three slab-spans, each with its own five foot data grid is shown in Figure 2-6. The longitudinal locations were determined relative to the edge of the transverse joint with the lower stationing at intervals of five feet. The transverse locations were determined relative to the left curb at five foot intervals, however the first transverse location used was two feet. This may be adjusted as desired to accommodate the slab-span being surveyed, e.g. the first transverse location may be one foot to include readings adjacent to the curb or four feet to include the wheelpath. In addition, the readings do not have to be made at fixed intervals if there is some reason to vary from the grid. However, it is easier to lay out the grid using fixed intervals and this convention should be followed in most cases.

TABLE 2-1

GRID INTERVALS

| Type of Measurement | Corrosion Potential | Chloride | Depth of Cover | Core | Delaminations, Spalls, and Patches |
|---|---|---|---|---|---|
| Suggested longitudinal interval (feet) | 5 | * | 10 | * | * |
| Suggested transverse interval (feet) | 5[a] | * | 5[a] | * | * |

* There is no fixed rate for these measurements, their number and location are to be determined in accordance with Chapters VI, VII, and VIII of this manual.

(a) Due to variations in the deck and its environment, it is desirable to locate the first transverse point two feet from the left curb or three feet from the left fascia. On the right side of the deck, an additional transverse location should be added approximately two feet from the curb if the last transverse location is four feet or more from the curb.

In the example shown in Figure 2-6, the slab-spans are skewed such that the first point encountered on the deck is the left hand corner which was assigned a longitudinal location zero. In many instances the slab-span will be skewed in the opposite direction as shown in Figure 2-7. When this occurs the survey crew must lay out a transverse line perpendicular to the centerline passing through the right corner of the slab-span at the beginning transverse joint. This line is assigned a longitudinal loaction zero where it intersects the imaginary extension of the left curb or fascia. The remaining longitudinal locations will all be determined relative to this point.

## B. Curved Slab-spans: Radius Less Than 1910 Feet

The grid system to be used for slab-spans with horizontal curves is similar to that used for the tangent slab-spans, longitudinal locations are measured as an arc along the left curb and transverse locations are measured along radial lines from the left curb or fascia. Although the method used is relatively simple, the existence of skewed joints and highly curved slab-spans can make it difficult to layout the grid by eye. The survey crew should determine the actual layout based on the record plans for the structure. The following examples will illustrate the method for laying out a grid on curved slab-spans.

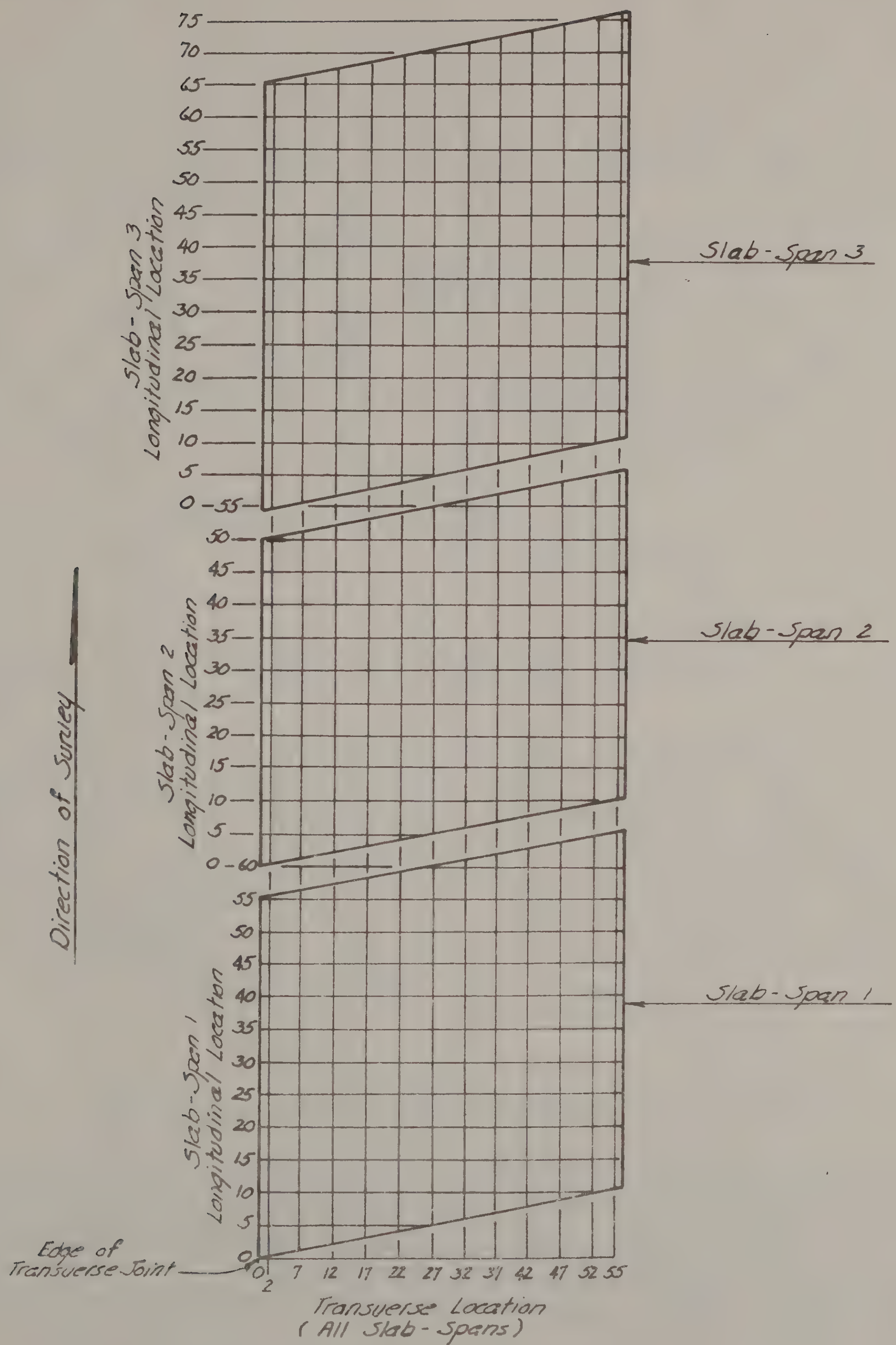



Figure 2-6. Tangent deck with five foot grid.

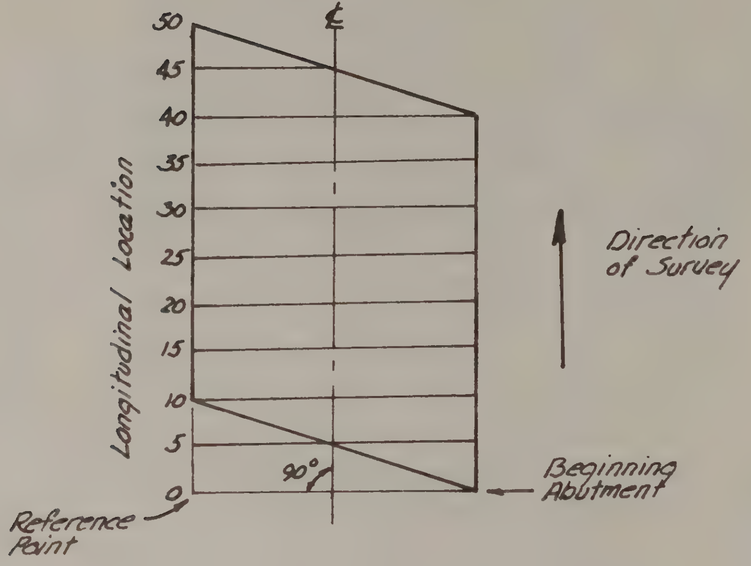



Figure 2-7. Longitudinal locations on tangent deck with positive skew.

Figure 2-8A shows a slab-span with zero skew at both ends, i.e. the transverse joints lie along radial lines perpendicular to the curb. In this case the survey crew lays out the longitudinal locations by measuring five foot intervals along the left curb or fascia, from the edge of the transverse joint. These points should be marked with a spot of paint or crayon. Next the intersection of a radial line drawn from the farthest longitudinal location and the right curb should be determined. The distance along the right curb from the transverse joint to that point should be divided by the number of whole longitudinal grid intervals along the left curb. This interval should be laid out along the right curb as shown. Alternatively, the interval to be used along the right curb may be found from the following:

$S_2 = S_1 \frac{R_2}{R_1}$ where $R_1$ = radius of the left curb,
$R_2$ = radius of the right curb,
$S_1$ = interval along left curb (usually 5')

The line connecting each successive pair of points along the right and left curbs is a radial line used to determine transverse locations. On some structures it may be impossible to work on both curbs at the same time due to traffic. In those cases the formula shown above may be used to determine the appropriate spacing on any curved reference line with a known radius such as the centerline. In this manner, the radial lines may be laid out a lane at a time if necessary.

Figure 2-8B and C show curved slab-spans with skewed transverse joints. In these cases radial lines constructed on the slab-span from the left curb will

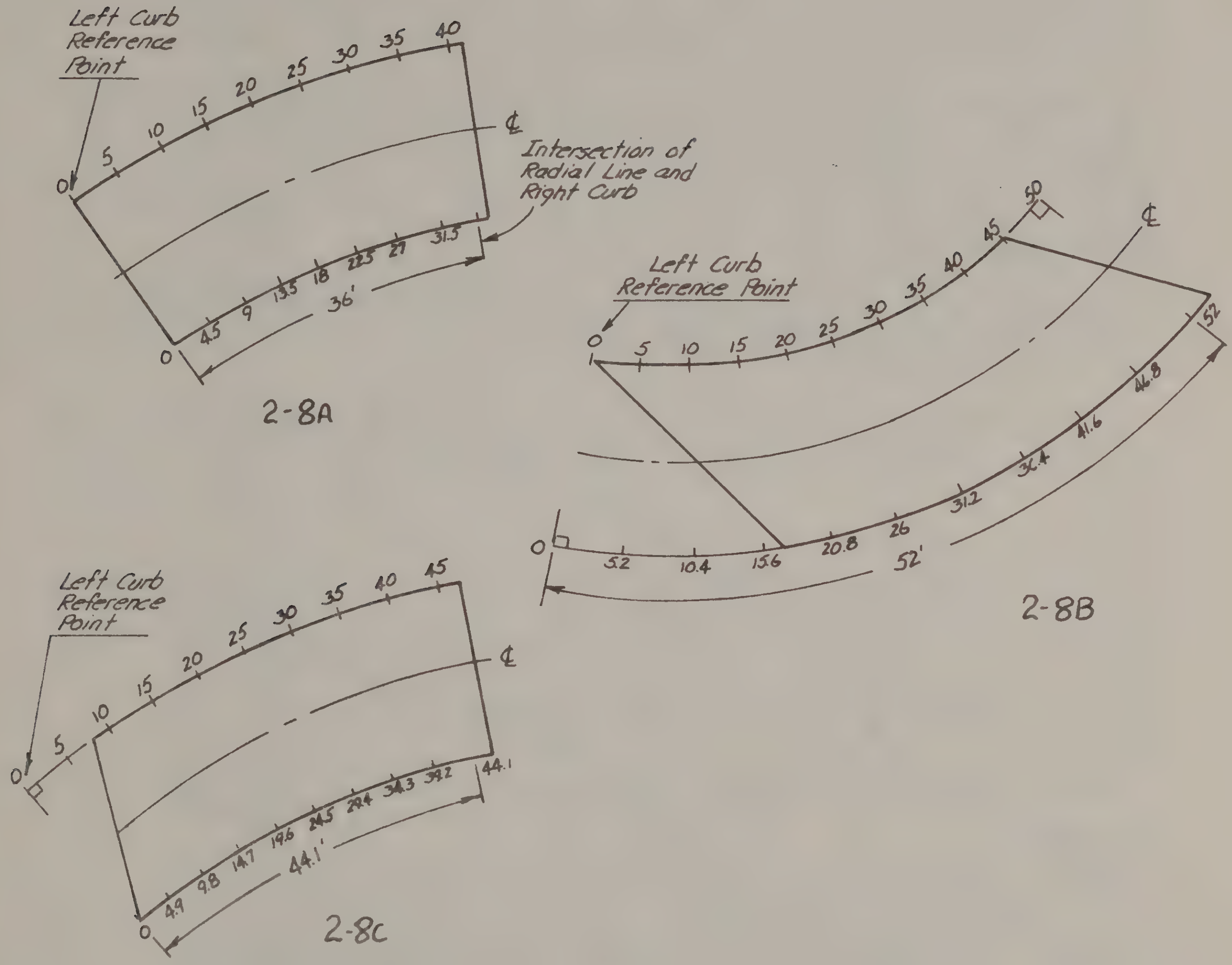



Figure 2-8. Longitudinal locations on curved decks.

not cover the entire slab-span. In Figure 2-8B the transverse joint at the beginning abutment is negatively skewed such that the radial line passing through the transverse joint at the left curb intersects the right curb approximately 17 feet from the transverse joint. At the far end of the slab-span the joint is skewed such that a radial line constructed at the 45 foot longitudinal location on the left curb does not provide grid points in the area of the last 10 feet of the slab-span on the right. For this reason an additional longitudinal location must be determined along the imaginary extension of the left curb or fascia at the 50 foot point. A radial line constructed from that point intersects the right curb or fascia approximately 52 feet measured along the right curb from the intersection of the radial

line passing through the zero longitudinal location. Since there are ten intervals laid out along the left curb, the 52 feet is divided by 10 to yield 5.2 feet intervals for the right curb. When laid out as shown these intervals locate the end points of the radial lines to be used for the grid.

In Figure 2-8C a similar problem is encountered at the beginning transverse joint. In this case the zero longitudinal location is determined to be the point where a radial line passing through the first point encountered on the slab-span (the right corner) intersects the imaginary extension of the left curb or fascia. All other longitudinal locations are then measured relative to this point.

The transverse locations are measured from the left curb or fascia along radial lines laid out perpendicular to the left curb. Figure 2-9 shows a skewed, curved slab-span with a five foot grid.

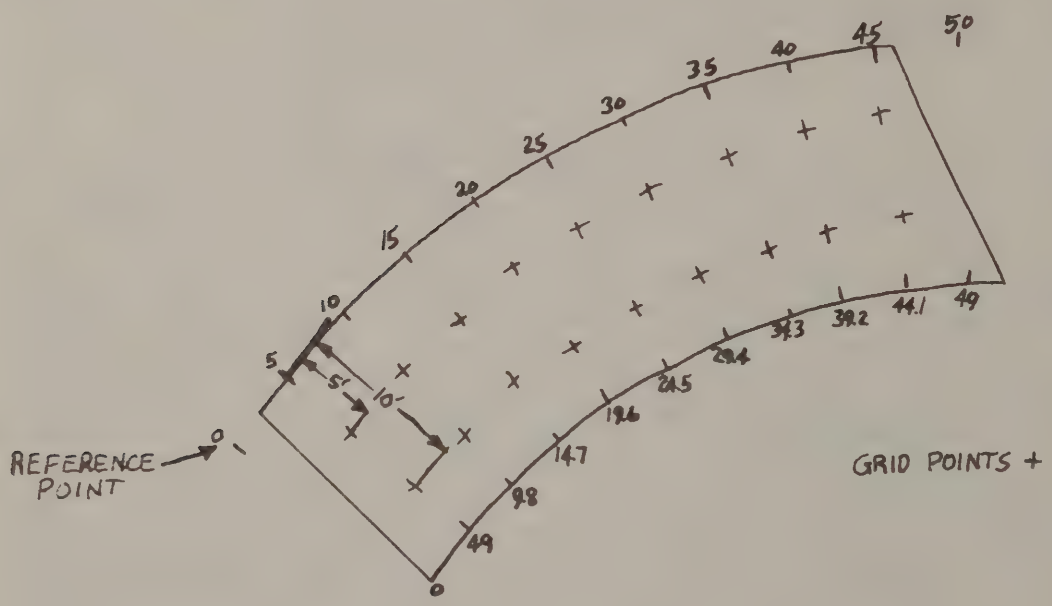



Figure 2-9. Curved deck with five foot grid.

C. Complex. Slab-spans

In some instances a survey crew may encounter a complex slab-span with both tangent and curved portions such as ramp entrances. In order to lay out a grid on this type of slab-span, it must be divided into a tangent portion and a curved portion each with its own grid. For this or other unique geometries which can't be handled by the procedures outlined above, contact the Development and General Engineering Section of the Materials Bureau at 457-4285 for assistance.

## III COMPLETING THE BRIDGE DECK CONDITION SURVEY FORM

Due to the amount of data to be collected during a bridge deck condition survey, a computer mapping program (SYMAP) is used to plot contours for the various types of data and to combine that data to produce concrete removal maps. In order to speed the data processing operation and reduce the number of times data is re-copied, a direct keypunch data form has been developed.

The Bridge Deck Condition Survey form (BR-334) is a two-part pressure sensitive form designed to be completed in the field. All information should be printed on the form as neatly and legibly as possible in conformance with the following rules.

ROUNDING-OFF PROCEDURE All data should be entered to the specified accuracy found in this manual, e.g. slab-span dimensions are recorded to the nearest foot. The rounding-off procedure to be used for all data shall be as follows.

1. When the next figure beyond the last figure to be retained is greater than 5, increase the last figure by 1.

2. When the next figure beyond the last figure to be retained is less than 5, the last figure remains unchanged.

3. When the next figure beyond the last figure to be retained is 5 and there are no figures beyond this, or only zeros, increase the last figure by 1 if it is an odd number or leave it unchanged if it is an even number. If there are additional figures beyond the 5, increase the last figure by 1.

EXAMPLES: Record the following lengths to the nearest foot using the rounding-off procedure.

| | | | |
|---|---|---|---|
| 91.62' | 0 | 9 | 2 |
| 87.43' | 0 | 8 | 7 |
| 43.50' | 0 | 4 | 4 |
| 42.5 ' | 0 | 4 | 2 |
| 34.51' | 0 | 3 | 5 |

ALPHABET All letters shall be upper case and shall conform to the alphabet shown here.

ABCDEFGHIJKLMNØPQR$TUVWXYZ

NUMBERS Numbers should look like these.

1234567890

BOXES

1. Enter only one letter or number in each box.
   EXAMPLE: Date May 8, 1976

   | 0 | 5 | / | 0 | 8 | / | 7 | 6 |

2. Fields containing only numbers should always be right justified in the boxes using leading zeroes to fill in the excess spaces.
   EXAMPLE: Left slab-span length of 99'

   | 0 | 9 | 9 |

3. Fields containing letters or a combination of letters and numbers are always left justified with excess spaces left blank.
   EXAMPLE: Contract number D96031

   | D | 9 | 6 | 0 | 3 | 1 | | | |

4. Do not leave blanks between the characters in a numeric field.

5. Where decimals have been preprinted on the form it is important that the data be properly spaced.
   EXAMPLE: The project identification number is 8001.32.301.

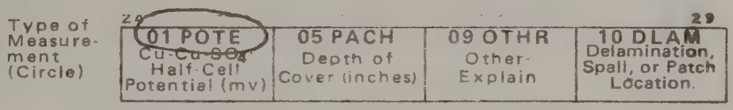
   | 8 | 0 | 0 | 1 | • | 3 | 2 | • | 3 | 0 | 1 |

6. All fractions are recorded as decimals.
   EXAMPLE: Depth of cover of 2¼".

   | 2 | 2 | 5 |

CIRCLED ITEMS

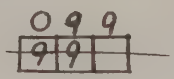
1. Circle the entire code printed in bold-face type for the appropriate choice.
   EXAMPLE: Type of measurement is corrosion potential.



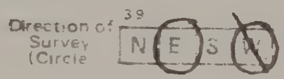

2. Only one code should be circled out of any one group.

ERRORS

1. If an error occurs in a boxed item draw a line through the incorrect entry in the boxes and record the correct data directly above the boxes.
   EXAMPLE: Number is improperly entered, i.e. left justified.

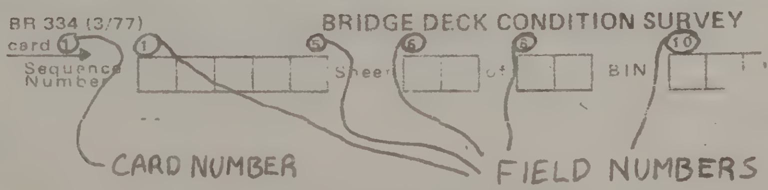



2. If an error occurs in a circled item, draw a line through the error and circle the correct entry.
   EXAMPLE: West was incorrectly circled, direction of survey is east.




## A. Completing the Heading

The top of the form contains information which identifies the bridge deck being surveyed, provides the necessary dimensions for plotting the data, and provides historical background for analysis of the data. Much of the required information may be obtained from the Bridge Inventory System maintained by the Structures Design and Construction Subdivision. The following are specific instructions for filling out each box in the heading. Each box is identified by a card number and a field number as shown below.



## CARDS 1-2 COMPLETING THE HEADING

| CARD | FIELD | DESCRIPTION |
|---|---|---|
| 1 | 1-5 | SEQUENCE NUMBER - The SEQUENCE NUMBER is a 5 digit number used to identify a single type of test performed on one slab-span at one time. The SEQUENCE NUMBER is assigned by the Region at the time of the work. The first digit is the Region number. The remaining four digits are sequentially assigned starting with 0001 each January.<br>EXAMPLE: A two slab-span structure and its approach slabs in Region 6 are surveyed for corrosion potential and depth of cover. This is the first structure surveyed in that calendar year. Sequence numbers 60001 through 60008 are assigned in the order in which testing is done. |
| 1 | 6-9 | SHEET ☐☐ OF ☐☐ - All sheets associated with a single test, on one slab-span, are numbered as they are completed. Any single sheet can contain data from only one slab-span; although more than one sheet may be required to record the data from a single slab-span. The sheet number is entered in the first two boxes using leading zeroes to fill in blanks. The other two boxes are filled when all work associated with that test on that slab-span is completed.<br>EXAMPLE: The fourth sheet of eleven total sheets of corrosion potential data on one slab-span.<br>Sheet [6] 04 of [8] 11 |
| 1 | 10-16 | BIN - The seven digit number assigned to each bridge to identify it in the Bridge Inventory System. This number is available from the Regional Bridge Inventory Coordinator. |
| 1 | 17-19 | STRUCTURE NUMBER - The number and letter code assigned to the bridge as part of the construction contract for reference purposes. All structures carrying one-way traffic must be assigned a letter code representing the direction of travel if none is given, e.g. E for eastbound. All structures carrying two-way traffic are assigned the letter T. If no structure number is available from the construction contract, assign the structure number one.<br>EXAMPLES: Structure carries northbound traffic only and has no number assigned in the original construction contract.<br>1 N |

| CARD | FIELD | DESCRIPTION |
|---|---|---|
| 1 | 17-19 | Structure carrying two-way traffic is designated 12 on contract plans. |
| | | 12T |
| 1 | 20 | APPROACH SLAB - When measurements are being made on the approach slab, place an A in this box. When measurements are being made on another portion of the structure, leave this space blank. |
| | | EXAMPLE: Corrosion potentials are being measured on the approach slab. |
| | | A |
| 1 | 21-23 | SLAB-SPAN NO. - The number assigned to the slab-span for reference as part of the construction contract. If the structure is continuous over a pier, i.e. there is no joint at the pier, use the lowest span number assigned to the slab-span under inspection. If no span numbers were assigned, the slab-spans are to be numbered sequentially starting with slab-span number 1 for the slab-span with the lowest stationing. When work is being done on the approach slab, use the number of the slab-span adjacent to that approach slab. |
| | | EXAMPLE: The structure shown in Figure 3-1 consists of a simple span (span no. 1) and two spans, (spans nos. 2 and 3) which are continuous over pier 2. Since there is no transverse joint over pier 2, spans 2 and 3 are combined to form slab-span no. 2 for survey purposes. Data is collected on slab-span no. 1. |
| | | 001 |

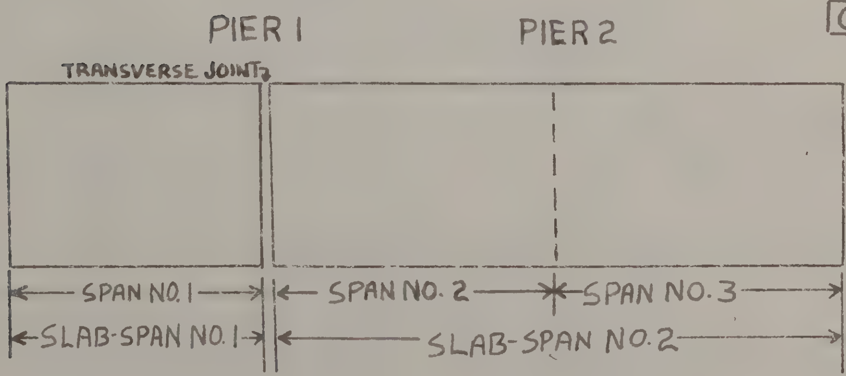



Figure 3-1. Numbering slab-spans.

| CARD | FIELD | DESCRIPTION |
|---|---|---|
| 1 | 24-29 | TYPE OF MEASUREMENT - Circle the appropriate number and letter code to indicate the type of measurement being performed. If the type of measurement is not shown, circle the code for Other and explain in Field 30-44. Only one code may be circled on each sheet. |

EXAMPLE: Depth of cover measurements are being taken.

| Type of Measurement (Circle) | 24 01 POTE Cu-Cu-$SO_4$ Half-Cell Potential (mv) | 05 PACH Depth of Cover (inches) | 09 OTHR Other-Explain | 29 10 DLAM Delamination, Spall, or Patch Location |
|---|---|---|---|---|

| CARD | FIELD | DESCRIPTION |
|---|---|---|
| 1 | 30-44 | OTHER - If the sheet is used to record data of a type not shown in TYPE OF MEASUREMENT, and 09 OTHR is circled, use this space to explain what the data is. |
| 1 | 45-55 | CONTRACT NUMBER - The construction contract number under which the deck was constructed. If more than one contract number was used on the construction project, the number which actually covered the bridge construction shall be used. |

EXAMPLE: Structure was constructed under contract number FARC 74-13.

| Contract Number | 45 F | A | R | C | 7 | 50 4 | - | 1 | 3 | | 55 |
|---|---|---|---|---|---|---|---|---|---|---|---|

| CARD | FIELD | DESCRIPTION |
|---|---|---|
| 1 | 56-64 | PIN - The nine digit Capital Project Identification Number most closely associated with the measurements, i.e. if a PIN has been assigned for the rehabilitation, use that number; if no PIN has been assigned, use the PIN associated with the CONTRACT NUMBER (Field 10-20). The decimal points are preprinted on the form in the proper locations. |
| 1 | 65-67 | LEFT SLAB-SPAN LENGTH - The distance in feet measured along the left curb line (or fascia if there is no curb) from the edge of the transverse joint with the lower stationing, to the edge of the next transverse joint. Report the length to the nearest foot using leading zeroes to fill in blanks. |

EXAMPLE: The distance measured along the left curb is 96.7'

| Left Slab-Span Length | 65 0 | 9 | 7 |
|---|---|---|---|

| CARD | FIELD | DESCRIPTION |
|---|---|---|
| 1 | 68-70 | RIGHT SLAB-SPAN LENGTH - The distance in feet measured along the right curb line (or fascia if there is no curb) from the edge of the transverse joint with the lower stationing, to the edge of the next transverse joint. Report the length to the nearest foot using leading zeroes to fill in blanks. |

| CARD | FIELD | CONSTRUCTION |
|---|---|---|
| 2 | 10-12 | SLAB-SPAN WIDTH - The distance in feet between the curbs (or fascia if there are no curbs) measured perpendicular to the centerline of the bridge. Report the width to the nearest foot using leading zeroes. |
| 2 | 13-16 | BEGINNING SKEW ANGLE - The angle between a perpendicular to the centerline of the roadway and a line through the centerline of the bearings at the transverse joint with the lower stationing. Skew angles measured in a clockwise direction from the perpendicular are considered positive; skew angles measured in a counter clockwise direction are negative. Circle the appropriate sign of the skew angle in Field 13 and record the angle to the nearest degree in Field 14-16. EXAMPLES: See Figure 3-2. |

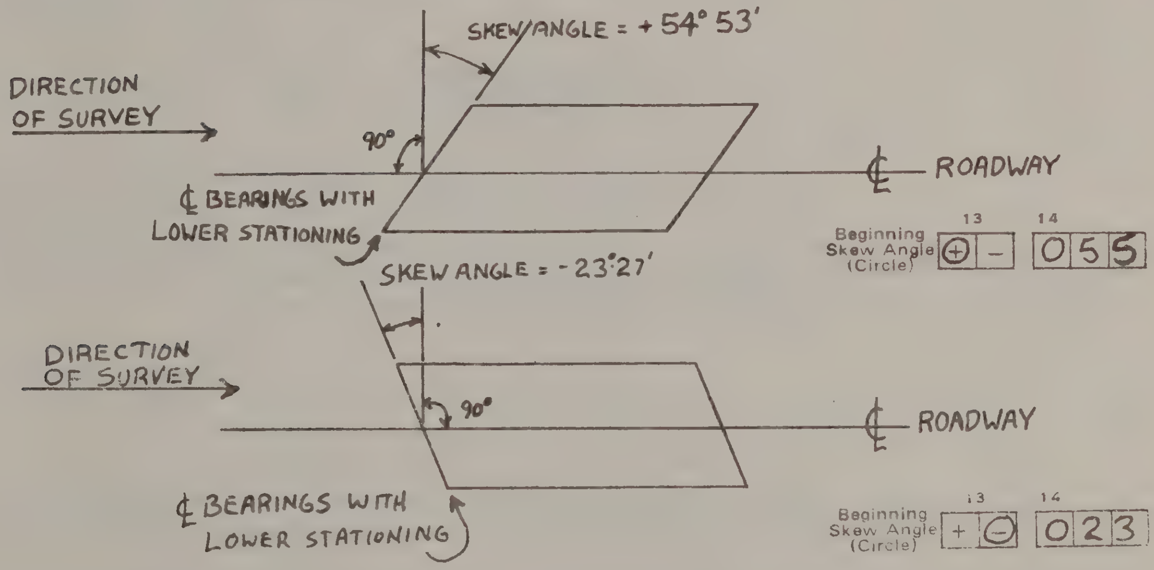



Figure 3-2. Determining skew angle.

| | | |
|---|---|---|
| 2 | 17-19 | BEGINNING TRANSVERSE JOINT LENGTH - The distance between curbs (or fascia if there are no curbs) measured along the transverse joint with the lower stationing. For bridges with zero skew angle this length will equal the slab-span width. For skewed joints this distance will always be greater than the slab-span width. Report the length to the nearest foot using leading zeroes. |
| 2 | 20-23 | CENTERLINE CURVE RADIUS - The radius of the horizontal curve measured from the center of the circle to the centerline of the slab-span. For tangent structures with no horizontal curve (radius greater than 1910 feet), enter zeroes in the |

| CARD | FIELD | DESCRIPTION |
|---|---|---|
| | | boxes. For curved structures, enter the radius to the nearest foot.<br>EXAMPLE: See Figure 3-3 |

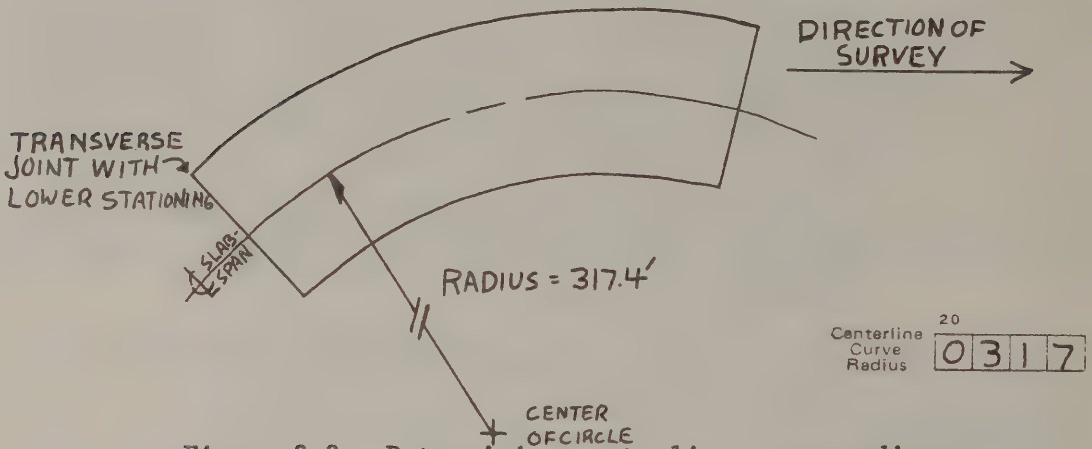



Figure 3-3. Determining centerline curve radius.

| CARD | FIELD | DESCRIPTION |
|---|---|---|
| 2 | 24 | CURVE DIRECTION - If the slab-span is curved, circle the appropriate curve direction as viewed by an observer looking in the direction of survey, i.e. increasing stations.<br>EXAMPLE: For the slab-span above, the curve direction is right. |


| CARD | FIELD | DESCRIPTION |
|---|---|---|
| 2 | 25-26 | YEAR OF CONSTRUCTION - Enter the last two digits of the year the structure was originally opened to traffic. |
| 2 | 27-28 | YEAR OF LAST WORK - Enter the last two digits of the year during which major work was done on the bridge such as deck replacement, lane addition, new wearing course, etc. Minor patching of the wearing course does not constitute major work. If no reconstruction has been done on the structure enter zeroes in the boxes. |
| 2 | 29-31 | REQUESTING ORGANIZATION CODE - The organization code of the unit within the Department requesting the measurement. This is the three digit code used with a function code on a timesheet. For tests done for the Thruway, use NYT as the code. |
| 2 | 32-33 | MEMBRANE - If the slab-span includes a waterproofing membrane, select the appropriate code from the list below and enter it on the sheet (additional codes will be assigned to |

| CARD | FIELD | DESCRIPTION |
|---|---|---|
| | | new membrane systems from time to time). If there is no waterproofing membrane, enter 00 to indicate none was used. |

00 None
05 Royston Membrane No. 10
10 Heavy Duty Bituthene
15 Protecto Wrap M400 or M400A
20 Bituminous Epoxy - 2 coats
21 Bituminous Epoxy - 1 coat
25 WABO 4000 LT
26 WABO 4000 HT
30 Superseal 4000 LT
31 Superseal 4000 HT
35 NEA 4000 LT
36 NEA 4000 HT
40 Petromat
99 Other

EXAMPLE: Heavy Duty Bituthene

32
Membrane (See Instructns) 10

| CARD | FIELD | DESCRIPTION |
|---|---|---|
| 2 | 34-35 | REINFORCING BARS - Determine the type of reinforcing bar used in the slab-span and enter the appropriate code from the list below. |

00 Plain steel reinforcing bars - Grade 40
05 Plain steel reinforcing bars - Grade 60
10 Epoxy coated reinforcing bars
30 Galvanized reinforcing bars
99 Other

| CARD | FIELD | DESCRIPTION |
|---|---|---|
| 2 | 36-37 | BAR SIZE - Determine the predominant size of the transverse bars used in the top mat of the reinforcing steel. The bar "size" is the numerator of the fraction expressing the bar diameter in eighths of an inch. |

EXAMPLE: 5/8" dia. bars are used in the top mat

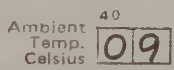
36
Bar Size 05

| CARD | FIELD | DESCRIPTION |
|---|---|---|
| 2 | 38 | SIP FORMS - Place an "X" in this box if the slab-span was constructed with stay-in-place metal forms. If not, place a zero in the box. |

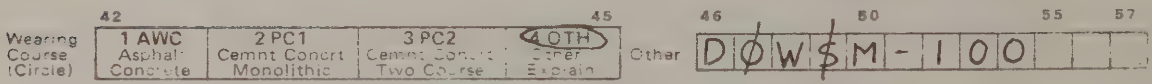
EXAMPLE: Stay-in-place forms were used.

38
SIP Forms X

| CARD | FIELD | DESCRIPTION |
|---|---|---|
| 2 | 39 | DIRECTION OF SURVEY - The compass direction in which the survey progresses, the direction of increasing stationing. Circle only one direction based on this criteria. |
| 2 | 40-41 | AMBIENT TEMP. - Record the average air temperature ($^{o}C$) in the vicinity of the slab-span during the time measurements are made. The temperature may be measured with any accurate thermometer. Temperature is reported to the nearest degree Celsius.<br>EXAMPLE: Average air temperature of $9^{o}C$. |


Ambient Temp. Celsius 40 | 0 | 9 |

| CARD | FIELD | DESCRIPTION |
|---|---|---|
| 2 | 42 | WEARING COURSE - Circle the appropriate number-letter code which most closely describes the wearing course construction. If none of the standard systems properly describes the wearing course, circle 4 OTH and describe in the adjacent box marked Other.<br>EXAMPLE: A concrete deck is overlaid with a DOW SM-100 latex concrete wearing course. |


Wearing Course (Circle) 42 | 1 AWC Asphalt Concrete | 2 PC1 Cemnt Concrt Monolithic | 3 PC2 Cemnt Concrt Two Course | 4 OTH Other Explain | 45
Other 46 D Ø W $ M - 1 0 0 50 55 57

| CARD | FIELD | DESCRIPTION |
|---|---|---|
| 2 | 58-63 | DATE - Enter the date on which the measurements were made. |
| 2 | 64 | SI UNITS - Leave blank. |
| 2 | 65-72 | LAB TEST NO. - This space is used to cross-reference field data with laboratory tests done by the Materials Bureau. Since this number would never be assigned until the field work was completed, this space should be left blank by field personnel. |

## B. Completing the Data Grid

The data grid contains a three block space for every combination of a transverse and longitudinal location. The proper entry of the data in that space is of paramount importance to the subsequent entry of the data in the computer.

All data is entered in the grid without decimal points, and blank positions in

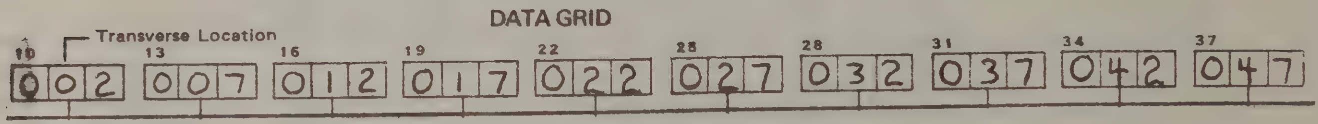
a space are filled with zeroes. Since decimal points are not entered, the data must be positioned as shown in the following examples where ▲ indicates the implied decimal point.

| TYPE OF MEASUREMENT | DESCRIPTION | DATA GRID ENTRY |
|---|---|---|
| 01 POTE<br>Cu-Cu-$SO_4$<br>Half-Cell<br>Potential (mv) | The corrosion potential is measured in volts and recorded to the nearest hundredth of a volt without a decimal point. Positive signs are not recorded, negative signs are recorded in the first block.<br>EXAMPLES: +0.34 volts. | 0 3 4 (▲ after 0) |
| | -0.09 volts. | - 0 9 (▲ after -) |
| 05 PACH<br>Depth of<br>Cover (inches) | The depth of cover over reinforcing steel is measured to the nearest eighth of an inch using a pachometer. The result is reported as a decimal fraction without a decimal point as shown. | |
| | Fraction 1/8 1/4 3/8 1/2 5/8 3/4 7/8 | |
| | Decimal Fraction 0.13 0.25 0.38 0.50 0.63 0.75 0.88 | |
| | EXAMPLE: 2 1/8" | 2 1 3 (▲ after 2) |
| 09 OTHR<br>Other-<br>Explain | If the form is to be used to record other types of data, contact the Development and General Engineering Section of the Materials Bureau for data entry instructions. | |
| 10 DLAM<br>Delamination,<br>Spall, or Patch<br>Location | Do not use the BR 334 to record delamination, spall or patch locations without prior approval of the Materials Bureau. | |

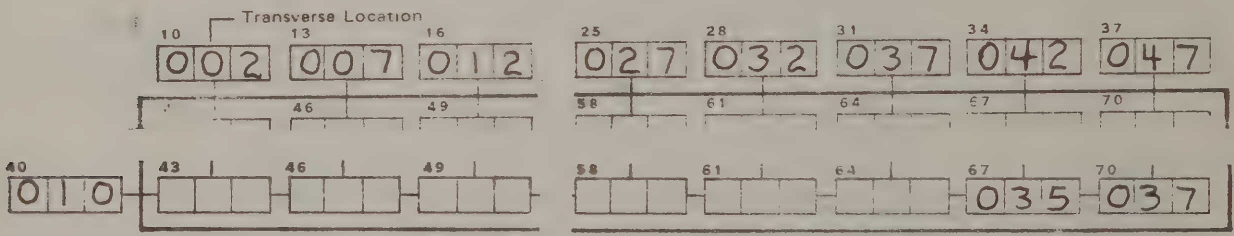
The data collected during the bridge deck condition survey must be related to the location of the measurement on the bridge deck in order to plot the data and prepare maps which will show areas requiring concrete removal. This is accomplished by assigning a transverse and longitudinal location to each data point (see Chapter II, Grid Layout). In order to record this information

on the form, the data is entered in ten columns representing ten transverse locations, and twenty rows representing twenty longitudinal locations.

A typical grid layout for a tangent structure is shown in Figure 3-4A. Assume corrosion potentials are to be measured on a five foot grid spacing. The transverse locations of the measurements are entered at the top of the data grid beginning with the first location in Field 10-12 and proceeding from left to right with increasing transverse locations as shown.




The form is designed so the lower left corner of the data grid corresponds to the left corner of the slab-span closest to the beginning abutment. Following this convention, the user records the first longitudinal location in the row closest to the bottom of the form. Ordinarily this would be the five foot distance, however only ten transverse locations (2 foot-47foot) can be recorded on the sheet. Since there is no data at the 5 foot longitudinal location within the first ten transverse locations, the user would select the 10 foot longitudinal location as his first row. This is entered in the bottom row of the extreme left hand column of the data grid (Field 40-43) as shown below.




The data for the transverse locations is then entered in the appropriate positions in that row, in this case potentials of +0.35 volts at 42 feet (Field 67-69) and +0.37 volts at 47 feet (Field 70-72).

Additional longitudinal locations are recorded in increasing order from the bottom to the top of the sheet in the extreme left column, 10 feet to 105 feet. The data for each point is then entered opposite the appropriate longitudinal location and under the appropriate transverse location. Data grid points off the structure such as the first eight locations in the bottom row are left blank. An example of a completed sheet is shown in Figure 3-5.

Due to the size of the slab-span used in this example, more than one sheet is required to record the data from a five foot grid. It is not necessary to completely fill out the heading for additional sheets representing one type

| SCHEME 1 | | | | |
|---|---|---|---|---|
| LOCATIONS \ SHEET NO. | 1 | 2 | 3 | 4 |
| TRANSVERSE | 2-47 | 52-57 | 2-47 | 52-57 |
| LONGITUDINAL | 10-105 | 5-100 | 110-135 | 106-115 |

| SCHEME 2 | | | | |
|---|---|---|---|---|
| LOCATIONS \ SHEET NO. | 1 | 2 | 3 | 4 |
| TRANSVERSE | 2-27 | 2-27 | 32-57 | 32-57 |
| LONGITUDINAL | 15-70 | 75-135 | 5-70 | 75-125 |

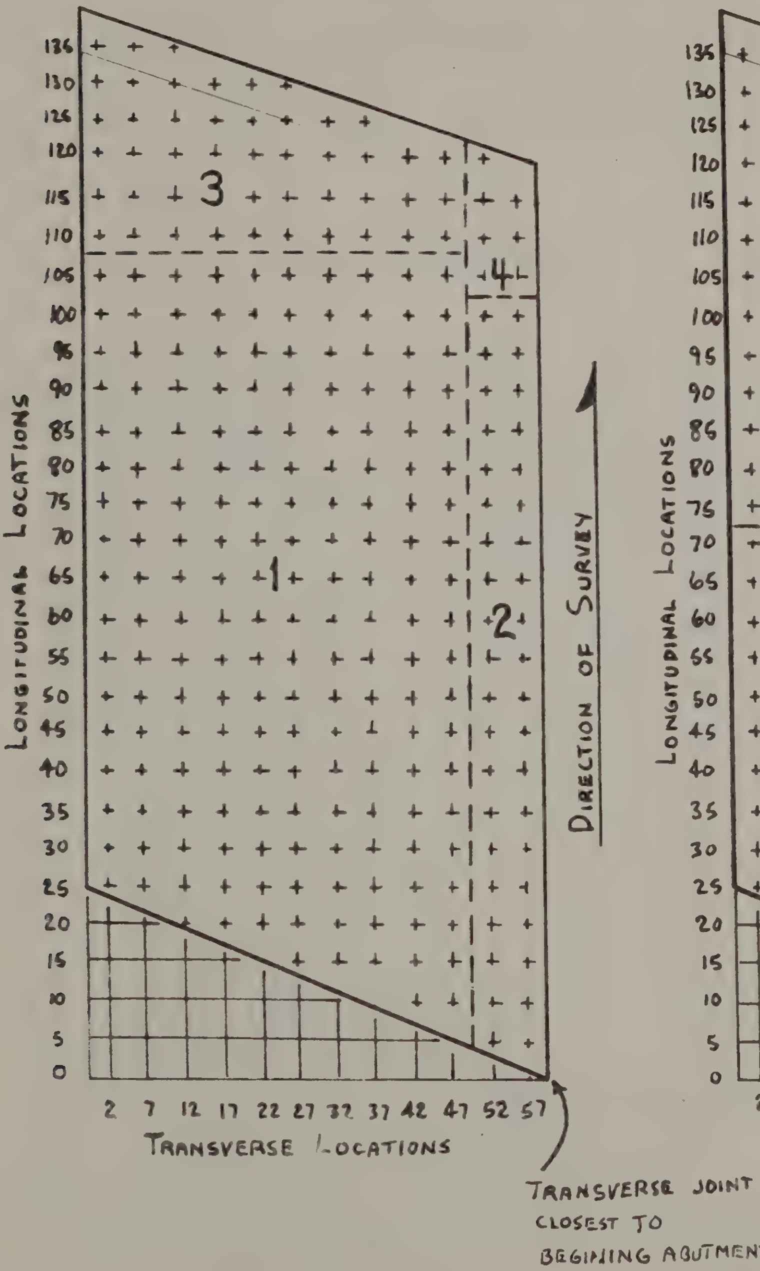



Figure 3-4A

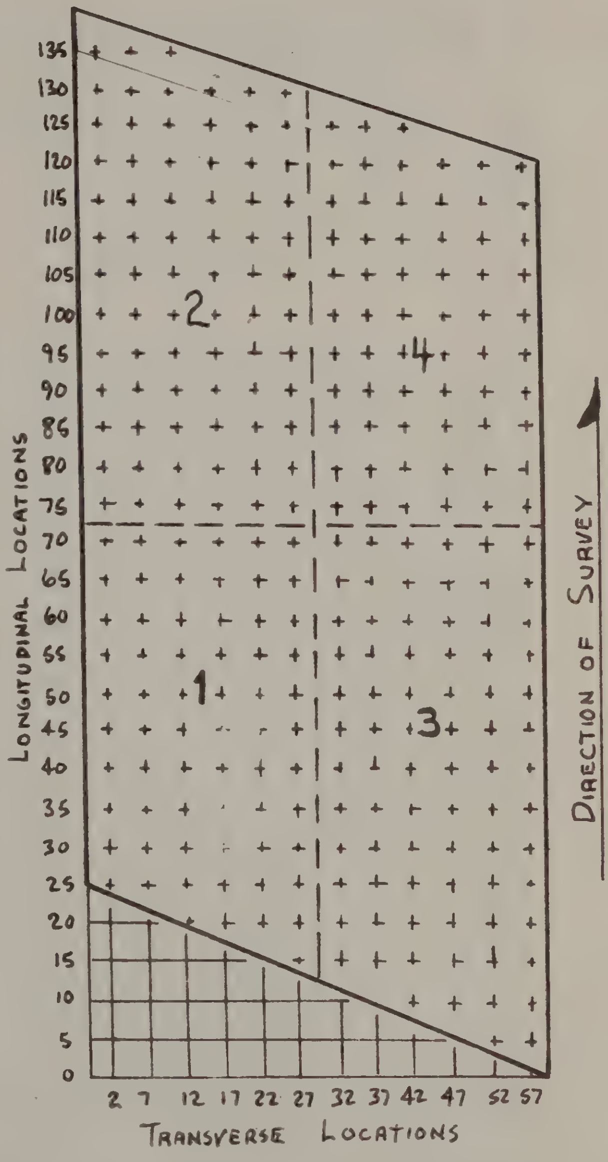



Figure 3-4B

Figure 3-4. Relating the deck grid to the data form.

BR 334 (3/77)

## BRIDGE DECK CONDITION SURVEY

### HEADING

card 1

Sequence Number: 10072 | Sheet 01 of 04 | BIN 1234567 | Structure Number: 1E | Approach Slab: | Slab Span No.: 001

Type of Measurement (Circle): 01 POTE Cu-Cu-$SO_4$ Half-Cell Potential (mv) | 05 PACH Depth of Cover (inches) | 09 OTHR Other-Explain | 10 DLAM Delamination, Spall, or Patch Location | Other:

---

Contract Number: FISH68-11 | PIN 1234•12•123 | Left Slab-Span Length: 115 | Right Slab-Span Length: 115 | 80: 1

card 2

Slab Span Width: 060 | Beginning Skew Angle (Circle): + - | 027 | Beginning Transverse Joint Length: 067 | Centerline Curve Radius: 0000 | Curve Direction (Circle): L R | Year of Constctn: 68

Year of Last Work: 74 | Requesting Organizatn Code: 123 | Membrane (See Instructns): 00 | Reinforcing Bars (See Instructns): 00 | Bar Size: 05 | SIP Forms: 0 | Direction of Survey (Circle): N E S W | Ambient Temp Celsius: 12

Wearing Course (Circle): 1 AWC Asphalt Concrete | 2 PC1 Cemnt Concrt Monolithic | 3 PC2 Cemnt Concrt Two Course | 4 OTH Other Explain | Other: | Date 10/10/77

SI Units: | Lab Test No.: | 80: 2

For the first sheet associated with a single sequence number, the entire heading must be completed. For additional sheets only the information above the dotted line must be completed.

### DATA GRID

card 3

| Longitudinal Location \ Transverse Location | 002 | 007 | 012 | 017 | 022 | 027 | 032 | 037 | 042 | 047 | 80 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 105 | 029 | 025 | 017 | 027 | 036 | 020 | 032 | 021 | 022 | 028 | 3 |
| 100 | 033 | 033 | 021 | 034 | 028 | 033 | 028 | 029 | 031 | 031 | 3 |
| 095 | 029 | 033 | 024 | 034 | 029 | 034 | 029 | 028 | 035 | 023 | 3 |
| 090 | 035 | 031 | 028 | 036 | 026 | 031 | 022 | 028 | 031 | 033 | 3 |
| 085 | 031 | 030 | 024 | 037 | 020 | 032 | 031 | 023 | 027 | 032 | 3 |
| 080 | 028 | 022 | 021 | 027 | 036 | 020 | 017 | 027 | 025 | 030 | 3 |
| 075 | 034 | 028 | 027 | 034 | 035 | 019 | 020 | 025 | 023 | 029 | 3 |
| 070 | 028 | 024 | 024 | 025 | 032 | 033 | 034 | 027 | 022 | 027 | 3 |
| 065 | 033 | 027 | 029 | 032 | 019 | 031 | 032 | 028 | 026 | 021 | 3 |
| 060 | 028 | 028 | 031 | 032 | 027 | 032 | 029 | 024 | 022 | 024 | 3 |
| 055 | 029 | 027 | 033 | 027 | 024 | 033 | 028 | 030 | 027 | 031 | 3 |
| 050 | 031 | 030 | 029 | 025 | 023 | 027 | 026 | 028 | 025 | 032 | 3 |
| 045 | 034 | 032 | 024 | 028 | 025 | 020 | 025 | 024 | 024 | 037 | 3 |
| 040 | 035 | 029 | 027 | 030 | 029 | 019 | 023 | 031 | 035 | 040 | 3 |
| 035 | 027 | 024 | 030 | 026 | 032 | 025 | 023 | 028 | 026 | 032 | 3 |
| 030 | 021 | 020 | 034 | 027 | 031 | 030 | 031 | 027 | 027 | 037 | 3 |
| 025 | 026 | 027 | 020 | 031 | 027 | 026 | 020 | 019 | 022 | 040 | 3 |
| 020 | | | | 024 | 020 | 024 | 030 | 032 | 038 | 032 | 3 |
| 015 | | | | | | 021 | 028 | 032 | 040 | 035 | 3 |
| 010 | | | | | | | | | 035 | 037 | 3 |

Person completing this form S. SCHULTZ

Person verifying this form K. RILEY

Figure 3-5. Completed data sheet.

BR 334 (3/77)

# BRIDGE DECK CONDITION SURVEY

## HEADING

card 1

Sequence Number: 10072 | Sheet 02 of 04 | BIN 1234567 | Structure Number 1E | Approach Slab | Slab Span No. 001

Type of Measurement (Circle): **01 POTE** Cu-Cu SO4 Half-Cell Potential (mv) | 05 PACH Depth of Cover (inches) | 09 OTHR Other-Explain | 10 DLAM Delamination, Spall, or Patch Location | Other

Contract Number | PIN | Left Slab-Span Length | Right Slab-Span Length | 80: 1

card 2

Slab Span Width | Beginning Skew Angle (Circle) + − | Beginning Transverse Joint Length | Centerline Curve Radius | Curve Direction (Circle) L R | Year of Constctn

Year of Last Work | Requesting Organizatn. Code | Membrane (See Instructns) | Reinforcing Bars (See Instructns) | Bar Size | SIP Forms | Direction of Survey (Circle) N E S W | Ambient Temp. Celsius

Wearing Course (Circle): 1 AWC Asphalt Concrete | 2 PC1 Cemnt Concrt Monolithic | 3 PC2 Cemnt Concrt Two Course | 4 OTH Other - Explain | Other | Date / /

SI Units | Lab Test No. | 80: 2

For the first sheet associated with a single sequence number, the entire heading must be completed. For additional sheets only the information above the dotted line must be completed.

## DATA GRID

card 3

| Longitudinal Location | Transverse Location 052 | Transverse Location 057 | 80 |
|---|---|---|---|
| 100 | 037 | 035 | 3 |
| 095 | 036 | 036 | 3 |
| 090 | 031 | 030 | 3 |
| 085 | 027 | 030 | 3 |
| 080 | 027 | 029 | 3 |
| 075 | 024 | 025 | 3 |
| 070 | 030 | 026 | 3 |
| 065 | 027 | 029 | 3 |
| 060 | 029 | 031 | 3 |
| 055 | 031 | 032 | 3 |
| 050 | 028 | 025 | 3 |
| 045 | 031 | 023 | 3 |
| 040 | 026 | 021 | 3 |
| 035 | 028 | 022 | 3 |
| 030 | 035 | 027 | 3 |
| 025 | 032 | 026 | 3 |
| 020 | 033 | 031 | 3 |
| 015 | 036 | 035 | 3 |
| 010 | 037 | 037 | 3 |
| 005 | 035 | 041 | 3 |

Person completing this form S. Schultz    Person ver... K. Riley

Figure 3-6. Completed second data sheet.

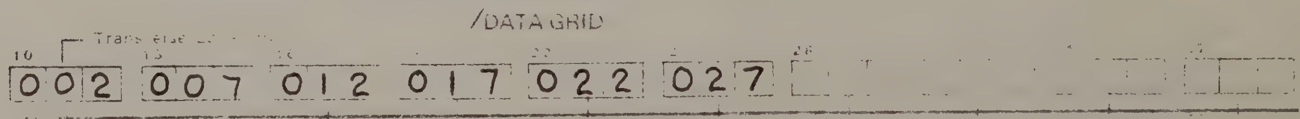
of measurement on a single slab-span. Only the information above the dotted line on the form must be filled out on additional sheets for one type of measurement on one slab span. The data grid is then completed using the appropriate transverse and longitudinal locations. For the slab-span shown in Figure 3-4A, the remaining data would be recorded on three additional sheets, The order in which the additional sheets are completed should reflect the order in which the data was taken. Therefore, for this example, if the survey crew now completes the right hand portion of the deck up to longitudinal location 100, the second sheet would look like Figure 3-6. Sheet 3 would contain data for longitudinal locations 110 to 135 and transverse locations 2 to 47 and sheet 4 would contain data for longitudinal locations 105 to 115 and transverse locations 52 to 57. When all sheets were completed, the crew would fill in the total number of sheets used for that type of measurement in Field 8-9 of Card 1 on each of the sheets.

A second or additional sheet can also be used to record additional data points not included in the grid. For example, if a corrosion potential survey done on a five foot grid gives very erratic results for a portion of the deck, additional measurements at intermediate longitudinal and transverse locations can be recorded on additional sheets, or in the unused portion of an existing sheet. The computer mapping program reorganizes the data in the proper order prior to mapping.

If measurements associated with a single sequence number must be performed on more than one day, and the average temperature of the different days varies by more than 5$^{o}$C, the crew should place each day's data on separate sheets. In addition to the information above the dotted line required for the additional sheets, the date and average ambient temperature should be shown on each sheet.

In this example, i.e. Figure 3-4A, the slab-span was divided so that the first data sheet would be filled as much as possible. However, the data can be divided in any manner that is convenient. For instance, if a sudden rain halted the survey crew after they had completed only the left side of the deck to transverse location 27 and longitudinal location 70, the data could be divided so that sheet 1 contains only data from logitudinal locations 15 to 70 and transverse locations 2 to 27. Any unused rows or columns on the sheet would be left blank. When the crew then surveyed the rest of the left half of the deck, they could begin a new sheet which would contain data from longitudinal locations 75 to 135 and transverse locations 2 to 27. This is shown in Figure 3-4B.

The same procedure for completing the data grid is followed for slab-spans with horizontal curves. Figure 3-7 shows a curved slab-span with a five foot data grid laid out in accordance with Chapter II of this manual. The transverse locations laid out on the radial lines are entered in the top row of the data grid as shown below:



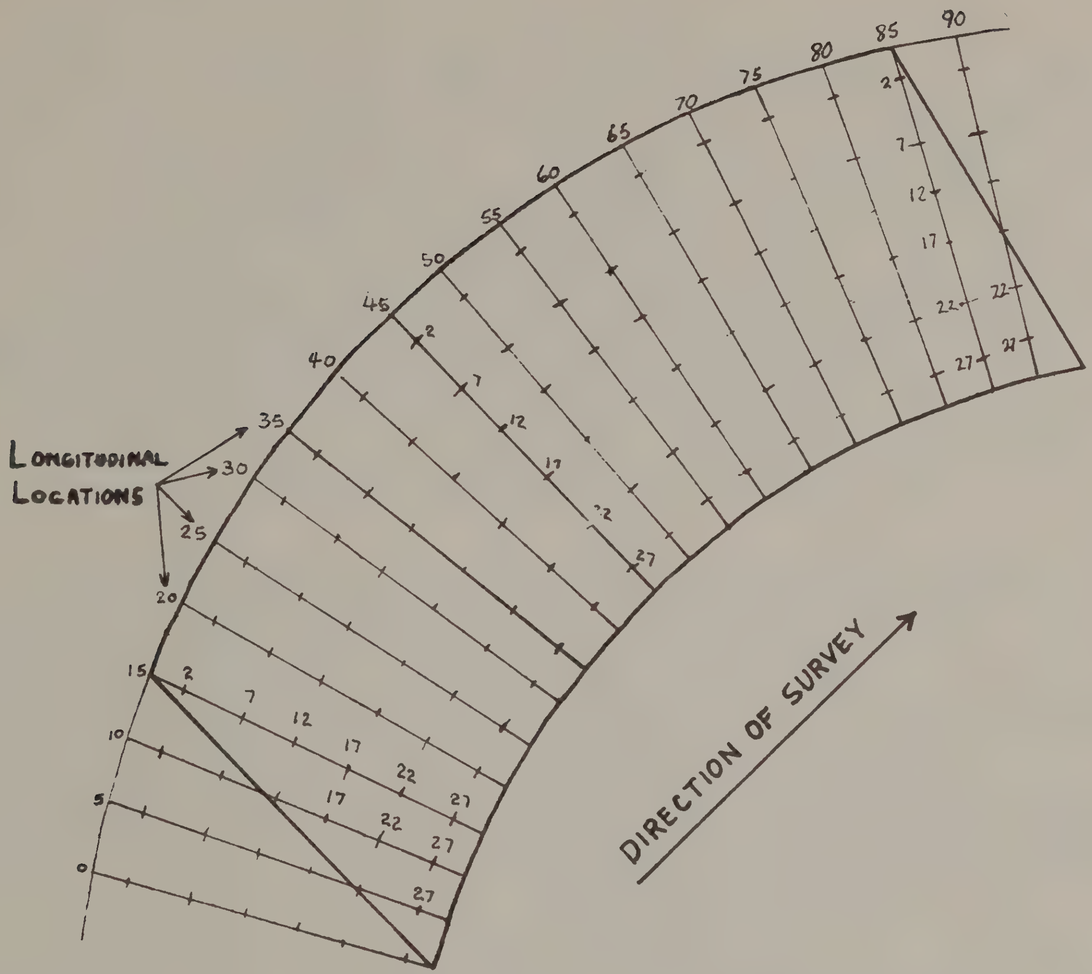



Figure 3-7. Curved slab-span with five foot data grid.

Next, the longitudinal locations are entered on the sheet. In Field 40-42 of the bottom row in the column labeled "Longitudinal Location", the first location on the left curb (5 feet) is entered. The remainder of the column is then filled in with additional longitudinal locations in increasing order from the bottom to the top of the column as shown in Figure 3-8. The data is now entered in the appropriate column and row of the grid.

When the data has all been recorded, the individual responsible for the survey should legibly enter his name at the bottom of each completed sheet in the space titled "Person completing this form." The completed forms are then forwarded to the Materials Bureau as described in ChapterIX.

BR 334 (3/77)

## BRIDGE DECK CONDITION SURVEY

### HEADING

card 1

| Field | Value |
|---|---|
| Sequence Number (1–5) | 90033 |
| Sheet (6) | 01 |
| of (8) | 01 |
| BIN (10–16) | 5432101 |
| Structure Number (17) | IN |
| Approach Slab (20) | |
| Slab Span No. (21–23) | 004 |

Type of Measurement (Circle) (24–29): 01 POTE Cu-Cu-$SO_4$ Half-Cell Potential (mv) | 05 PACH Depth of Cover (inches) | 09 OTHR Other-Explain | 10 DLAM Delamination, Spall, or Patch Location

Other (30–44):

| Field | Value |
|---|---|
| Contract Number (45–55) | FARC64-72 |
| PIN (56–64) | 9876•54•321 |
| Left Slab-Span Length (65) | 070 |
| Right Slab-Span Length (68–70) | 094 |
| (80) | 1 |

card 2

| Field | Value |
|---|---|
| Slab Span Width (10) | 030 |
| Beginning Skew Angle (Circle) (13) | + − |
| Beginning Transverse Joint Length (14) | 021 |
| Centerline Curve Radius (17) | 033 |
| Curve Direction (Circle) (20) | 0114 |
| (24) | L R |
| Year of Constctn. (26) | 64 |
| Year of Last Work (27) | 73 |
| Requesting Organizatn. Code (29) | 987 |
| Membrane (See Instructns) (32) | 10 |
| Reinforcing Bars (See Instructns) (34) | 05 |
| Bar Size (36) | 07 |
| SIP Forms (38) | X |
| Direction of Survey (Circle) (39) | N E S W |
| Ambient Temp Celsius (40) | 27 |

Wearing Course (Circle) (42–45): 1 AWC Asphalt Concrete | 2 PC1 Cemnt Concrt Monolithic | 3 PC2 Cemnt Concrt Two Course | 4 OTH Other Explain

Other (46–57):

Date (58–62): 08/01/77

SI Units (64): | Lab Test No. (65–72):

(80): 2

For the first sheet associated with a single sequence number, the entire heading must be completed. For additional sheets only the information above the dotted line must be completed.

### DATA GRID

card 3

Transverse Location (columns 10, 13, 16, 19, 22, 25, 28, 31, 34, 37); Longitudinal Location (column 40); data columns 43–70; column 80.

| Longitudinal Location | 002 | 007 | 012 | 017 | 022 | 027 | | | | | 80 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | 3 |
| | | | | | | | | | | | 3 |
| 090 | | | | | 087 | 125 | | | | | 3 |
| 085 | 187 | 100 | 075 | 050 | 063 | 113 | | | | | 3 |
| 080 | 175 | 075 | 063 | 087 | 125 | 163 | | | | | 3 |
| 075 | 187 | 087 | 050 | 113 | 137 | 187 | | | | | 3 |
| 070 | 200 | 113 | 037 | 125 | 113 | 163 | | | | | 3 |
| 065 | 187 | 100 | 025 | 113 | 087 | 150 | | | | | 3 |
| 060 | 225 | 113 | 075 | 137 | 075 | 187 | | | | | 3 |
| 055 | 237 | 087 | 087 | 163 | 087 | 200 | | | | | 3 |
| 050 | 187 | 075 | 063 | 150 | 087 | 213 | | | | | 3 |
| 045 | 175 | 087 | 087 | 125 | 087 | 225 | | | | | 3 |
| 040 | 163 | 100 | 075 | 113 | 100 | 213 | | | | | 3 |
| 035 | 187 | 075 | 037 | 125 | 113 | 175 | | | | | 3 |
| 030 | 187 | 063 | 075 | 150 | 125 | 175 | | | | | 3 |
| 025 | 213 | 087 | 087 | 163 | 113 | 137 | | | | | 3 |
| 020 | 200 | 100 | 087 | 113 | 125 | 163 | | | | | 3 |
| 015 | 200 | 125 | 137 | 163 | 150 | 175 | | | | | 3 |
| 010 | | | | 125 | 113 | 163 | | | | | 3 |
| 005 | | | | | | 213 | | | | | 3 |

Person completing this form J. SMYTHE

Person verifying this form G. L. BROWN

Figure 3.8 Completed data sheet for a curved slab-span.

## IV REINFORCING STEEL CORROSION POTENTIALS

Delamination and spalling of portland cement concrete bridge decks are caused primarily by expansive forces due to corrosion of the reinforcing steel. Chloride ions from deicing salts accelerate corrosion by activating the surface of the steel reinforcement and increasing the electrical conductivity of the concrete deck. Since the corrosion products of steel are more voluminous than the steel itself, large tensile stresses develop in the concrete at the level of the top reinforcing bars, and cracking and delamination result.

Actively corroding and passive areas of the reinforcing steel may be located by conducting a corrosion potential survey of the deck on a five by five foot grid using a copper-copper sulfate half-cell. The half-cell has a constant voltage which, when connected to the reinforcing steel, provides a reference for measuring the corrosion potential of the steel. The circuit used consists of a ground wire which is attached directly to the reinforcing steel and the negative (common) terminal of a high impedance voltmeter. A second wire connects the positive terminal of the voltmeter to the copper-copper sulfate half-cell. The circuit is completed by moisture in the concrete deck when the porous end of the half-cell is placed on the deck. The equipment required for the corrosion potential survey is shown in Figure B-1 of Appendix B (pg. 69).

Corrosion potential values equal to or greater than 0.35 volts more negative than the copper-copper sulfate half-cell, indicate a high probability that reinforcing steel corrosion is occurring in that area at the time of the measurement. When corrosion potentials are less than 0.20 volts more negative than the half-cell, there is a high probability that the steel is passive and no corrosion is occurring. The range between 0.20 volts and 0.35 volts is a gray area where corrosion may or may not be occurring. A more detailed explanation of the corrosion reaction and the use of the copper-copper sulfate half-cell to measure corrosion potentials is given in Appendix A of this manual.

### A. Ground Connection to Reinforcing Steel

It is essential that a low resistance electrical circuit be established. The effect of a poor ground or a loose connection is to increase the resistance in the circuit which raises the measured potential by an unknown amount. This problem is compounded by the fact that induced error is not easily recognized.

The ground for taking potential readings is obtained by making a direct connection to a reinforcing bar in the slab-span where readings are to be taken. Although it is possible to establish a low resistance circuit by

grounding to a bridge rail or some other metal appendage that is connected to the reinforcing steel, such a circuit may be influenced by potentials generated by dissimilar metals or different grades of steel. These grounds are not to be used, as they can induce large errors into the corrosion potential readings.

If reinforcing bars are not exposed or accessible for making a ground connection, locate a transverse bar with the pachometer in any easily accessible area such as an asphalt patch or where the concrete cover is shallow. If possible the ground should be located adjacent to the cones separating traffic from the work area. In this way the same connection may be used when traffic is shifted to the other lane. A cold chisel and hammer will expose the bar under an asphalt patch in a short period of time. A roto-hammer such as a Skil model number 728 with bull point will readily expose a rebar in sound concrete. Incline the cold chisel at about 45 degrees to the bar and chisel until a portion of the rebar has been curled up as shown in Figure 4-1. An alligator or spring clamp can be used to make the connection. If the entire bar is easily exposed, the clamp can be placed on the sides of the bar after they have been cleaned to bright metal.

A circuit check for resistance should be made by using two such connections, or from the reinforcing bar to a scupper or rail anchor bolt. A good ground and low resistance circuit will have a resistance of less than 5 ohms and have consistent values, within two ohms, on two ranges of the meter. The leads should be reversed at the meter to check the resistance on both polarities; these values should also be within two ohms of each other.

When a circuit check is being done, connections to scuppers or rail bolts should be made with a C-clamp or sturdy clamp type connector. Rust, dirt, and non-conductive coatings should be removed by using emery cloth or a file so that bright metal is exposed.

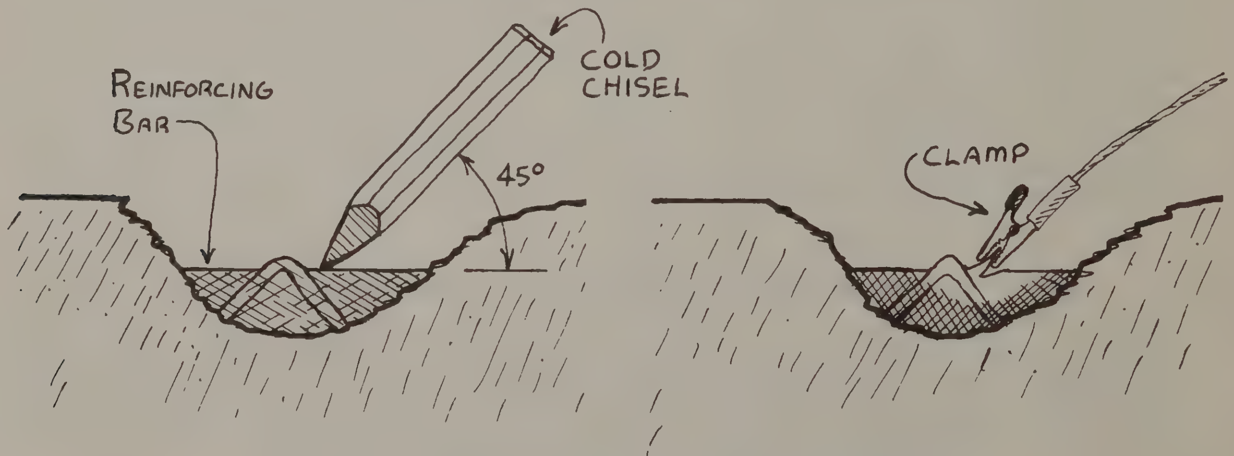



Figure 4-1. Reinforcing bar ground connection.

## B. Establishing A Low Resistance Circuit

1. Zero the meter and check the battery as per instructions with the meter. The meter should be allowed to come to equilibrium with the ambient-temperature before starting.

2. Find two possible ground connections for a resistance check, preferably both reinforcing bars.

3. Curl up the top of the reinforcing bars with a chisel and hammer.

4. Clean the ground connection to bright metal with emery cloth or a file. The curled up reinforcing bar is usually clean enough.

5. Set the meter function switch to read ohms and set the range to 0-100 ohms or some equivalent scale so the meter resolution is 1 ohm or less. Zero the meter.

6. Attach a lead from the negative (common) terminal of the meter to the reinforcing bar to be used as the ground for potential readings.

7. Attach one end of the wire reel to the positive terminal of the meter.

8. Attach a short lead from the other end of the wire reel to the second ground. See Figure 4-2 for a schematic of the hook-up.

9. Turn the meter on and read ohms of resistance. If the reading is less than 5 ohms, change the meter range, zero the meter, and read again. If the readings are within 2 ohms, reverse the leads at the meter and read again. If all the readings are below 5 ohms and within 2 ohms of each other, the ground connection and circuit are satisfactory.

   If any resistance reading exceeds 5 ohms, the readings differ by more than 2 ohms, or no reading is obtained when the leads are reversed (display flashes to indicate reading in excess of 100 ohms); there is an improper ground or a bad connection somewhere in the circuit. To test the circuit resistance, unhook from one ground and rehook to the clamp of the other ground. If the resistance is still over 5 ohms, you have a bad connection in the circuit. If the resistance reading drops below 5 ohms, one or both of the grounds are not acceptable.

   If no reading was obtained when the leads were reversed, or the readings changed appreciably, the rail bolt or scupper is probably not adequately connected to the reinforcing steel in the deck. Hook to a second rebar or another rail bolt and recheck your circuit.

## C. Pre-wetting Grid Points

Pre-wet each grid point on the deck with a small quantity of electrical contact solution, which is tap water containing a wetting agent or liquid

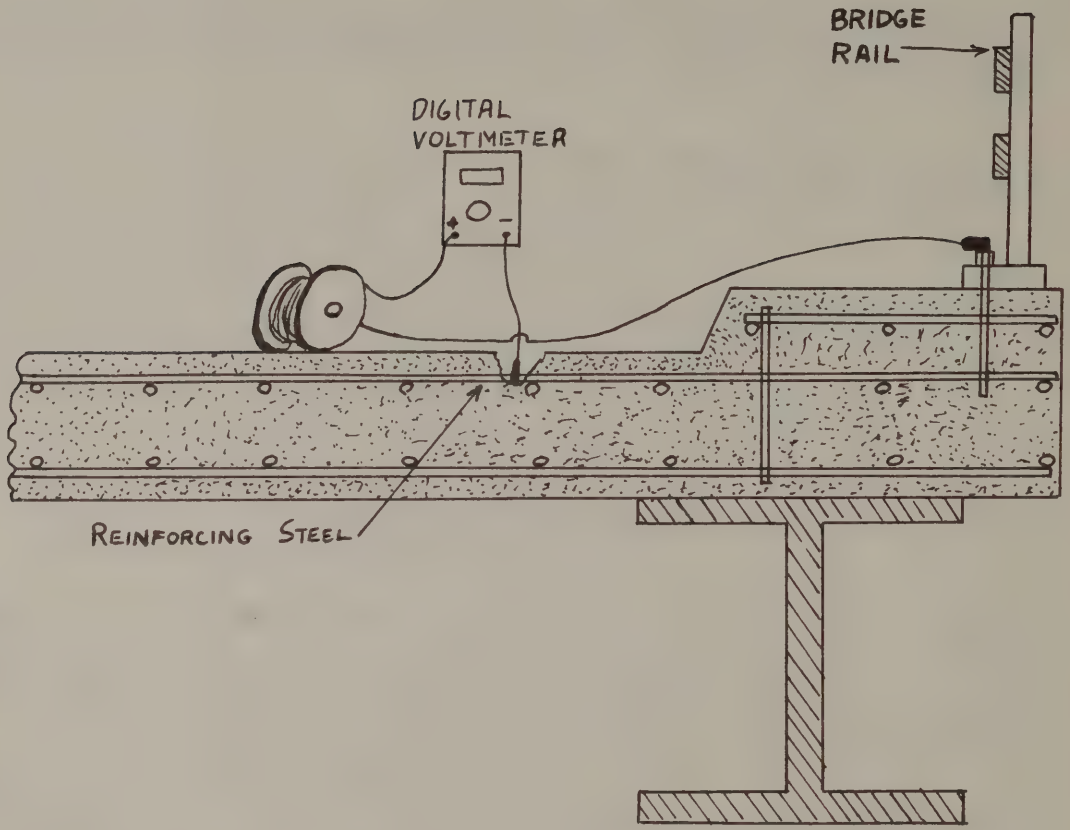



Figure 4-2. Checking circuit resistance and ground.

household detergent. The ratio of liquid detergent to water is 1:200 by volume. This would be 3.2 ounces (95 milliliters) of detergent per 5 gallons (19 liters) of water. At temperatures below 50°F (10°C), approximately 15% by volume of either isopropyl or denatured alcohol should be added to the solution to improve penetration of the solution into the concrete.

Pre-wet 5-10 minutes prior to using the half-cell to allow the solution to penetrate the concrete surface. If the solution should evaporate from any of the grid points prior to obtaining a reading, the solution should be applied again. Do not over apply solution such that standing water is present when readings are taken or grid points are connected by surface water.

## D. Equipment Preparation

1. Check copper-copper sulfate half-cells to see that they are filled with saturated copper sulfate solution and that excess copper sulfate crystals are present. If more solution is required, add distilled or deionized

water and reagent grade copper sulfate crystals so there are always some excess crystals present in the bottom of the half-cell.

2. Remove plastic cap from porous end of half-cell and place a sponge saturated with electrical contact solution over the end.

3. Allow half-cells to come to equilibrium with ambient temperature.

4. Set meter function switch to read DC volts and set range to 1000 mV.

5. Zero the meter as per instructions with meter.

6. Attach a short lead from reinforcing bar ground to negative or common terminal of meter.

7. Attach one end of wire reel to positive terminal of meter.

8. Attach a short lead from the other end of wire reel to a half-cell. See Figure 4-3 for schematic of equipment.

## E. Precision Check

1. Place the porous end of the half-cell covered with the wet sponge on one of the pre-wet grid points and observe the meter display. If the reading is stable, i.e. does not change by more than 0.01 volts after 15 seconds, make a note of the observed voltage.

2. Disconnect the half-cell, re-connect it and repeat the measurement at the same point on the deck. If the readings vary by more than 0.010 volts, the equipment is not functioning properly and should be checked.

3. When the equipment is properly functioning, replace the first half-cell with another half-cell and repeat the measurement at the same grid point. The readings should not vary by more than 0.020 volts. Failure to satisfy these requirements may indicate a faulty half-cell, e.g. unsaturated copper sulfate solution, or a defective ground to the reinforcing steel. When any problems have been corrected and satisfactory precision checks obtained, the crew may proceed with the corrosion potential survey.

## F. Obtaining Potential Readings.

1. Switch meter range to 10 volts and zero the meter. Place the half-cell on the first grid point, the potential reading should stabilize in a few seconds. If the reading does not stabilize the concrete may not be sufficiently wet and more electrical contact solution should be applied to the grid points.

2. The half-cell is moved along the deck and placed in firm contact with the concrete at each grid point until a stable reading is obtained.

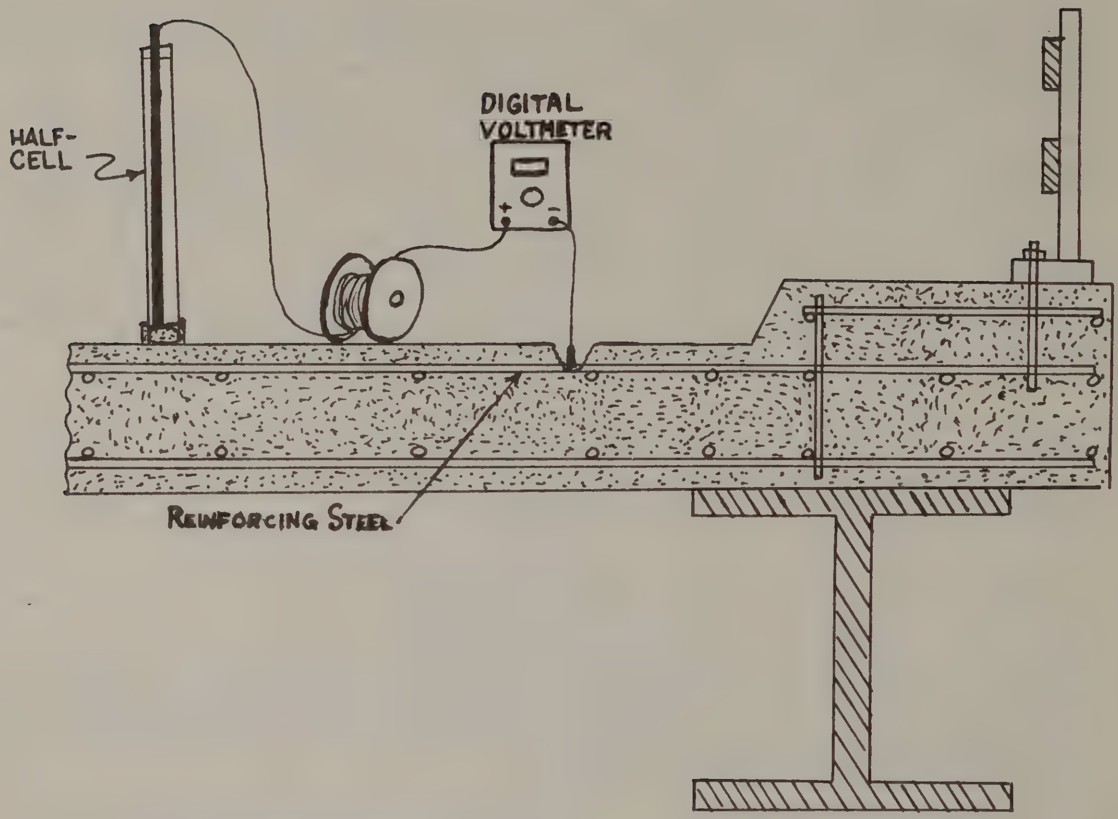



Figure 4-3. Corrosion potential equipment.

3. The corrosion potential for each grid point should be recorded in the appropriate position in the data grid on the bridge deck condition survey form. The potential should be recorded in the three blocks exactly as it appears in the meter display except that the decimal point is omitted. In general the readings should fall between 0.10 and 0.60 volts, however it is possible on rare occasions to obtain negative readings at some locations. When this occurs the negative sign should be entered in the first block of the space in the data grid followed by the reading (the zero preceding the decimal point is omitted).

4. Occasionally the survey crew should re-measure the potential of certain points to insure that their readings are reproducible. Readings made on the same point on the same day should not vary by more than 0.02 volts. These additional values are not recorded on the form. If readings vary, the crew should check their equipment and connections to determine the cause of the variability.

5. Completed data forms should be processed as outlined in Chapter IX.

## G. Precautions

1. Decks that have free standing water due to rainfall are not suitable for measuring corrosion potentials. The excess moisture conducts current from areas of high potential and the voltmeter will register the high potentials even when no corrosion is present below the half-cell. Once the deck surface appears dry, several additional hours of drying are required before potential readings will be repeatable.

2. Do not attempt to take readings through asphalt or epoxy patches, or directly on an exposed reinforcing bar. The variation in the electrical resistance of the bar environment will cause the readings to be unreliable. If a suitable reading cannot be made within one foot of the actual grid point, leave the corresponding space on the survey form blank.

3. A separate ground connection must be made for each slab-span.

4. Corrosion potential measurements should not be made at temperatures below 4°C (40°F) due to possible freezing moisture in the deck. The difference between the electrical resistance of water and ice in the concrete will change the potential reading.

## V DEPTH OF CONCRETE COVER OVER REINFORCING STEEL

The time required for deicing salts to penetrate to the level of the reinforcing steel is related to the depth of concrete cover. Therefore the final grade of any repair work must be designed to provide sufficient concrete cover. The depth of cover can be determined by a pachometer, an instrument which measures the change in its magnetic field due to the proximity of a steel object. Since the size and shape of the steel object affect the magnitude of the change, the pachometer must be calibrated using reinforcing bars of the same size and oriented in the same pattern as the top reinforcing steel in the deck. The equipment required for the depth of cover survey is shown in Figure B-2 of Appendix B (pg.71).

### A. Pachometer Calibration

1. Turn the pachometer on test and let it warm-up for approximately 5 minutes.

2. Remove the probe from box and hold it in the air away from all metal objects.

3. Rotate the "zero set" knob until meter needle is on "set" on left side of scale.

4. Place the probe against the two by four calibration block such that the one-inch spacing is between the probe and the bar. Be sure the probe is centered over and parallel to the bar.

5. Adjust the "Sensitivity Knob" until the meter needle is over the one-inch mark on the scale.

6. Remove the probe from the block and readjust the "Zero Set" knob until meter needle is on "set" on left side.

7. Repeat steps 3-6 to fine tune if necessary.

8. Arrange the five reinforcing bars such that they represent the spacing of the top reinforcing mat of the deck. The two lower bars represent the longitudinal steel and the 3 top bars should be spaced and oriented to represent the top transverse steel. Proper spacing can be determined from the contract plans. The bars should look similar to those shown in Figure 5-1.

9. Place a 3/4" thick piece of wood over the bars and place the pachometer probe directly over the middle transverse bar and between the longitudinal

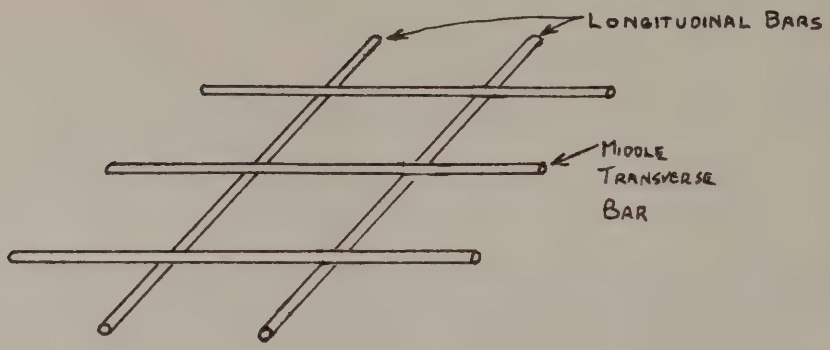



Figure 5-1. Reinforcing bars for pachometer calibration.

bars. Move the probe sideways in both directions until the lowest reading is obtained. Verify that the meter is reading correctly. Repeat this procedure for other depths in 1/4" increments up to the maximum depth anticipated. If the meter reads incorrectly by more than 1/8" you will have to make a note of this and apply a correction factor to your data. If the meter reads incorrectly by more than 1/4", send the instrument to the Materials Bureau for internal calibration.

## B. Determination of Depth of Cover

1. Pachometer readings are taken at the same transverse spacing but at twice the longitudinal spacing, i.e. ten foot intervals, as the corrosion potential measurements.

2. At each grid point, locate the longitudinal reinforcing bars and mark with Keel (lumber crayon).

3. Place the probe between the longitudinal steel and parallel to the transverse steel. Move the probe sideways until the lowest depth of cover reading is obtained. The probe is now directly over a transverse bar.

4. Read the meter scale for the appropriate bar size and determine the depth of cover to the nearest 1/8 inch. The depth is recorded on the bridge deck condition survey form as a decimal fraction as though there was a decimal point between the first and second boxes in the data grid.

5. Several times during the day, check the calibration as outlined in section A of this chapter.

6. Areas adjacent to spalled areas with exposed rebars are good areas to check the accuracy of meter. The exposed bar depth can be measured with a ruler and should be very close to the pachometer reading taken on the same bar in the area adjacent to the spall.

7. Completed data forms should be processed as outlined in Chapter IX.

## C. Precautions

1. Any ferrous metal objects in close proximity to the probe will affect the readings. Readings adjacent to grates, metal joints, etc. will probably be incorrect.

2. Aggregates such as iron ore tailings may affect accuracy.

3. Temperature changes may affect the calibration of the meter. Recalibrate periodically if the ambient temperature is changing.

4. Transverse reinforcing bars in skewed bridges may run on a skew or perpendicular to the centerline. Orient the probe accordingly (parallel to transverse bars) when testing.

5. Measurements should not be taken at temperatures below 4°C (40°F) because the pachometer is not sufficiently sensitive at those temperatures to give accurate readings.

## VI CHLORIDE ANALYSIS

The quantity of chloride ions present in the concrete at the depth of the reinforcing steel is one of the factors affecting the corrosion of reinforcing steel. The quantity is related to the age of the structure, the amount of deicing salts applied, and the permeability of the concrete. However, since most of these parameters are fairly constant for any one structure, it is not necessary to make as many measurements of chloride content as compared to corrosion potential or depth of cover measurements. In addition, since the concrete cover must be removed in areas of spalling and delaminations anyway, chloride samples are only taken from apparently sound areas. The analysis for chloride content is performed by the Materials Bureau on powdered samples of concrete taken from the deck.

### A. Location And Number Of Samples

Chloride samples are taken along a single transverse line at points approximately one foot from each curbline and in one wheelpath in each twelve foot wide traffic lane. Figure 6-1 shows examples of this for two, three, and four lane structures.

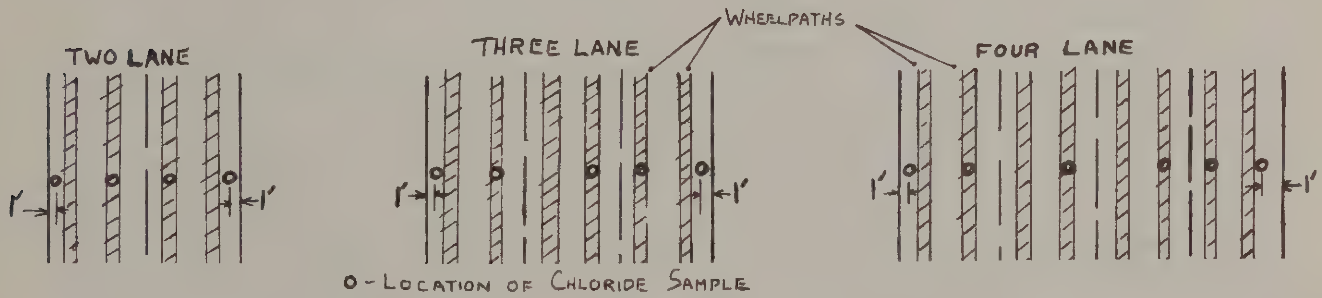



Figure 6-1. Location of chloride samples.

On single slab-span bridges a single transverse line of samples should be taken in an area free from spalls, delaminations or excessive deterioration. If the entire deck is deteriorated, the samples should be taken in the area on the slab-span in the best condition.

On bridges with multiple slab-spans, a transverse line of samples should be taken approximately every two slab-spans. For example on a bridge with five slab-spans, a transverse line of samples should be taken on two of the slab-spans; on a deck with eight slab-spans, four slab-spans should be sampled.

The samples consist of the powdered concrete removed from a drill hole at depths of 3/4 to 1-1/4 inches (nominal 1 inch), 1-3/4 to 2-1/4 inches (nominal 2 inch), and 2-3/4 to 3-1/4 inches (nominal 3 inch). Care must be taken in locating the exact site of each hole to avoid striking the top reinforcing steel with the drill.

## B. Sample Procedure

1. Select sample locations. Use a pachometer to locate the reinforcing steel.

2. Set the depth gage on the hammer drill to 3/4" and drill to this depth with 3/4" diameter drill bit.

3. Blow the concrete powder out of the hole with a rubber syringe or other air blower apparatus. Make sure the hole and surrounding concrete is clean of any drilled dust.

4. Clean any accumulated powder from the drill bit. Set the depth gage to 1-1/4" and drill to this depth.

5. Remove the accumulated powder from the hole with a small bent spoon or similar tool and place it in a separate 12 x 75mm culture tube or other container. Do not touch the powder with your hands. Label the culture tube with the location number and depth of sample as stated in C. Recording Samples. If the cap is not airtight, wrap masking tape around the tube and cap to seal it.

6. Set the depth gage to 1-3/4" and drill to this depth. Clean the hole and surrounding area of powder. Clean the drill bit.

7. Set the depth gage to 2-1/4" and drill to this depth. Repeat step 5.

8. Repeat the above procedure to retrieve the sample from the 2-3/4 - 3-1/4" depth.

9. Samples and the chloride sample log should be processed as outlined in Chapter IX.

## C. Recording Samples

1. Set up a chloride sample log as shown in Figure 6-2 to record the location of each chloride sample as it is taken. A blank space is left for the chloride content following each depth entered in the log. If a sample is taken at a depth other than the nominal one, two, and three inch depths, it should be shown in the log.

2. As each sample is placed in a culture tube, the location number assigned by the survey crew and the nominal depth at which the sample was taken

CHLORIDE SAMPLE LOG

BRIDGE: ROUTE 99 OVER PCRR BIN: 999 999

DATE: 3/9/77 TAKEN BY: ERNIE PANOU

| TRAFFIC DIRECTION | SLAB-SPAN NO. | GRID LOCATION LONG. | GRID LOCATION TRANS. | LOCATION NO. | DEPTH/CHLORIDE CONTENT | | |
|---|---|---|---|---|---|---|---|
| EB | 1 | 30 | 1 | 1 | 1/ | 2/ | 3/ |
| | | | 5 | 2 | 1/ | 2/ | 3/ |
| | | | 15 | 3 | 1/ | 2/ | 3/ |
| | | | 25 | 4 | 1/ | 2/ | 3/ |
| WB | 2 | 45 | 1 | 5 | 1/ | 2/ | 3/ |
| | | | 10 | 6 | 1/ | 2/ | 3/ |
| | | | 22 | 7 | 1/ | 2/ | 3/ |
| | | | 25 | 8 | 1/ | 2/ | 3/ |

Figure 6-2. Chloride sample log.

should be written on the tube using a permanent ink marking pen. For example, the chloride sample taken at a nominal depth of 2 inches, at longitudinal location 30, transverse location 15 on the eastbound slab-span number 1 in Figure 6-2 would be labeled 3-2".

## VII DELAMINATION DETECTION AND SPALL LOCATIONS

The pressure exerted by the corrosion products of the reinforcing bars can cause the surrounding concrete to crack. In some cases these cracks may be horizontal and extend between adjacent bars in the top mat causing a delamination of the concrete above the bars from the rest of the slab. The action of traffic on the deck may cause the delaminated concrete to disintegrate forming a visible spall on the deck surface. However, at any given time there may exist numerous delaminations in a deck which are not visible, these may be located by using a chain drag.

The use of a chain drag to locate delaminations is based on the fact that the sound produced by dragging the chains over the surface of the deck becomes deeper or fuller as they pass over a hollow area in the deck. Experience has shown that this method of locating delaminations is very accurate. In some instances, delaminations may fall between the grid points used for corrosion potential measurements and may not be found by the potential survey. In that case the chain drag is the only method available for locating these hidden defects. It is therefore very important that the entire deck be thoroughly checked using the chain drag.

In addition to delaminations, surface spalling and cracking of the concrete should be recorded since it may not be possible to make pachometer and corrosion potential measurements in areas of severe surface spalling. This includes areas which have been patched with bituminous concrete or epoxy mortar because these materials must be removed as part of the deck rehabilitation.

### A. Procedure

1. The chain drag is swung from side to side in front of the observer such that the chain links strike the concrete surface producing a jingling sound. When the sound changes noticeably to a deeper or more resonant sound the chains are over a delamination.

2. The limits of each delamination should be marked on the surface of the deck using a lumber crayon.

3. Spalls, cracks, and any other deterioration are located by visual observation. This includes spalls which have been temporarily patched with concrete or permanently patched with an epoxy mortar.

## B. Documentation

The following defects should be sketched on a copy of the 1"=10' drawing of each slab-span:

1. Cracks
2. Delaminations
3. Spalls
4. Bituminous concrete or epoxy mortar patches
5. Any other deterioration noted.

During the preparation of the contract plans these defects will be transferred to plan sheets or added to the concrete removal maps by hand. Since this drawing will be used to estimate quantities of repair work, it should be fairly accurate as to the size and location of the defects. The completed drawing is processed as outlined in Chapter IX.

# VIII DATA VERIFICATION-CALIBRATION CORES

Although the methods described in Chapters IV through VII are adequate to determine the kind and extent of concrete removal required, it is necessary to verify the accuracy of the data and to resolve any apparent contradictions in the results. This is accomplished by taking several partial depth cores at selected locations on the bridge deck. The following material describes the procedures for selecting the core locations.

## A. Core Location

In general, shallow depth of cover and high corrosion potentials are associated with delaminations, spalls, and cracks in the concrete. The survey crew will usually find this to be the case with the data they collect. However, when contradictory results occur at a particular location, the deck should be cored in that area to determine which, if any, of the data is incorrect. Examples of such contradictary data are:

(1) thick cover (2"+) and high potential reading (0.40 volts)
(2) thin cover (1") and low potential reading (0.15 volts)
(3) delamination and low potential reading (0.25 volts)
(4) adjacent grid points with a large difference in potential (0.25 to 0.40 volts).

In addition to the cores taken to resolve any discrepancies in the data, calibration cores should be taken from each area representing a different class of concrete removal on each slab-span. The number of cores taken should be kept to a minimum. The intent of this procedure is simply to confirm the survey data at representative locations. On multiple slab-span structures or multi-lane structures the number of cores taken on each slab-span should be reduced accordingly to keep the coring effort manageable. In addition, any areas of the deck where the degree of deterioration or quality of the concrete is questionable, should be cored and the cores evaluated in accordance with the "Bridge Deck Evaluation Procedure Manual" issued by the Structures Design and Construction Subdivision. Any color photographs taken of the cores should be taken as soon as practicable, preferably no later than twenty-four (24) hours after removal from the deck.

## B. Core Record

A core record such as that in Figure 8-1 should be completed for each slab-span. The record should include the location of the core, pachometer, data, actual depth of cover, corrosion potential, condition of steel, presence of delamination and cracks, and any pertinent remarks. Each core must be broken open at the top reinforcing bar level to examine the condition of the steel.

| CORE NO. | LOCATION | | DEPTH OF COVER | | DELAMINATION | | CORROSION POTENTIAL | STEEL CORROSION | CRACKS | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| | LONG. | TRANS. | PACH. | ACTUAL | CHAIN DRAG | CORE EXAM. | | | | |
| 1 | 15 | 5 | 2 1/4" | 2" | No | No | 0.22 | NONE | NONE | CLEAN STEEL |
| 2 | 25 | 5 | 1" | 1 1/8" | YES | YES | 0.38 | MEDIUM | NONE | BAR PITTED ALL AROUND |
| 3 | 45 | 10 | 1 1/4" | 1 1/4" | No | YES | 0.33 | LIGHT | NONE | PITS ON TOP OF BAR |
| 4 | 45 | 20 | 1 1/2" | 1 3/8" | YES | YES | 0.43 | HEAVY | NONE | LOOSE RUST |
| 5 | 50 | 15 | 2" | 1 7/8" | No | No | 0.41 | MEDIUM-HEAVY | YES | CRACK AT BAR |
| 6 | 75 | 20 | 1 3/4" | 1 1/2" | No | No | 0.39 | LIGHT-MEDIUM | NONE | ADJACENT TO SPALLED AREA |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |

Figure 8-1. Core record.

## C. Interpretation of Results

Corrosion potential readings generally indicate the following degrees of corrosion.

| Corrosion Potential | Condition of Steel Reinforcement |
|---|---|
| Less than 0.20 volts | No corrosion |
| 0.20 - 0.30 volts | Little or no corrosion |
| 0.30 - 0.40 volts | Light to moderate corrosion |
| Greater than 0.40 volts | Moderate to heavy corrosion |

Most of the cores taken should agree with these guidelines if the potential data is correct, however, some individual cores may not. It is possible to pick up corrosion activity at some distance from its location, and it is also possible that a previously rusted area may have stopped corroding and may exhibit a low potential. If most of the cores comply with the criteria shown above, the corrosion potentials may be assumed to be correct. Similarly, the majority of the cores should agree with the pachometer results for the depth of cover.

The completed core record should be processed as outlined in Chapter IX.

# IX PROCESSING SURVEY DATA

The data and samples collected by the survey crew must be forwarded to the Materials Bureau for analysis and generation of the appropriate maps. In order to simplify the transfer, all materials related to a single structure and its approach slabs should be combined in one package. In the case of exceptionally large structures with numerous slab-spans, the material may be further broken down into groups of slab-spans to speed processing.

The original (white) copy of each BR-334 Bridge Deck Condition Survey form is sent to the Materials Bureau and the yellow copy is retained in the Region for their records. All other written materials included in the package should be copies with the originals retained in the Region.

The materials to be included in the package are:

1. Corrosion potential data (BR-334)
2. Depth of concrete cover data (BR-334)
3. Powdered concrete chloride samples and the chloride sample log.
4. Delamination, spall, patch, and crack locations (1"=10' scale drawing of the deck showing the location and outlines of all defects)
5. Core record (completed table as shown in Figure 8-1, pg. 52)

The package should be sent to the attention of either Field Services I for Regions 1, 2, 8, 9, and 10 or Field Services II for Regions 3, 4, 5, 6, and 7 at this address:

New York State Department of Transportation
Materials Bureau
1220 Washington Avenue
Albany, NY 12232

The concrete removal maps and chloride results will be returned to the Region upon completion. Questions concerning the status of the data or interpretation of the results should be referred to the appropriate Field Services unit at 457-5956.

## APPENDIX A - REINFORCING STEEL CORROSION

## THEORY AND MEASUREMENT

The corrosion of reinforcing steel in bridge decks due to deicing salt intrusion has been identified as the major cause of bridge deck spalling and delamination. For this reason it was necessary to develop a non-destructive test to determine if the reinforcing steel in an existing bridge deck was corroding. The California Department of Transportation adopted the copper-copper sulfate half-cell corrosion potential measurement test to this purpose. This appendix describes the theory behind that measurement and the field procedures for the measurement of reinforcing steel corrosion potentials.

### A. Corrosion Reaction

The corrosion of reinforcing steel in concrete is an electrochemical process, which means it involves a chemical reaction and a transfer of electrical energy. The surface of the reinforcing steel is made up of many individual sites or electrodes which have different electric potentials with respect to their environment due to variations in the alloy structure, stress, environment, etc. These sites are known as anodes or cathodes depending on their electric potential. When two of these are externally coupled by an electrolyte or conducting medium, the electrode with the higher potential will supply electrons to the corrosion reaction and is called the anode, the other electrode which receives the electrons is called the cathode.

It is the difference in electric potential between these sites which promotes the corrosion reaction. Referring to Figure A-1, the metallic iron (Fe) at the anode has been converted to an iron ion ($Fe^{++}$) with two positive charges or "oxidized", i.e. it has had electrons removed. The two electrons which the iron lost travel through the reinforcing steel to the cathode as an electric current under the influence of the potential difference. The ions travel in the electrolyte (water) such that the positive ions ($Fe^{++}$ or $H^+$ from the water) move to the cathode. At the cathode the electrons may unite with two hydrogen ions ($H^+$) from the water to form hydrogen gas ($H_2$). Another reaction which is possible may produce hydroxide ions ($OH^-$). Both of these reactions increase the number of hydroxide ions in solution, and it is those ions which unite with the iron ions ($Fe^{++}$) to form rust ($Fe(OH)_2$).

The potential of a corroding electrode can be measured by using a reference electrode placed near the corroding electrode. As the reference electrode is moved toward one of the electrically coupled electrodes, it will interrupt the current flow between the two and the potential gradient between them may be followed. At the anode where active corrosion is occurring the higher

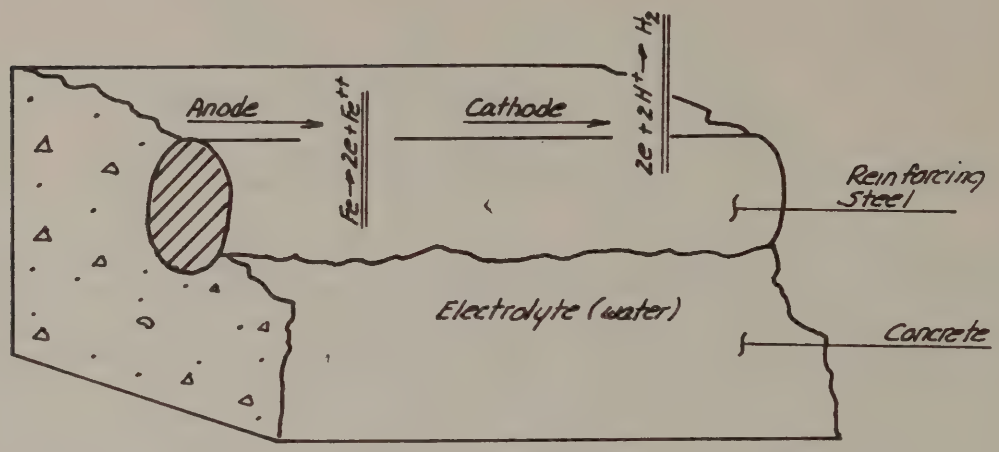



Figure A-1. Corrosion reaction.

electric potential will be found.

Under normal conditions, reinforcing steel in concrete corrodes at a very slow rate due to a characteristic of the steel known as "passivity." Due to the high pH of the concrete (approximately 12) the oxidation reaction of the steel at the anode is affected. When first exposed in the wet concrete the steel initially corrodes very rapidly until it reaches the "critical corrosion rate" where the steel passivates i.e. a thin oxide layer is formed which acts as a partial barrier to further corrosion. If the environment of the steel does not change, the passivated reinforcing steel will corrode at such a slow rate that it will not produce the voluminous product necessary to damage the concrete within the design life of the structure.

When deicing salts enter the concrete, they upset the chemical equilibrium between the concrete and the reinforcing steel. The chloride ions ($Cl^-$) improve the electrical conductivity of the electrolyte and destroy the passivity by complexing the iron ion at the surface of the anode to produce $FeCl_2$. The $FeCl_2$ then reacts in solution with water ($H_2O$) to produce the normally observed $Fe(OH)_2$ and $Fe(OH)_3$, i.e. rust. The ultimate effect of these changes in the chemical environment is a marked increase in the corrosion rate of the steel and the early deterioration of the structural deck.

## B. Copper-Copper Sulfate Half-Cell

The electric potential which exists between a metal and its ions in solution cannot be measured directly because potential is not an absolute quantity. Potential must be measured relative to something of known or assigned potential. Since most corrosion reactions encountered involve water or aqueous solutions where hydrogen is present, the potential of the standard hydrogen

half-cell reaction ($2H^{+}+2e \rightarrow H_2$) is defined as zero.

Using this as a reference, the corrosion potential of a metal can be measured using equipment such as that shown in Figure A-2. If the hydrogen half-cell is used as the reference cell in this equipment, the voltage read

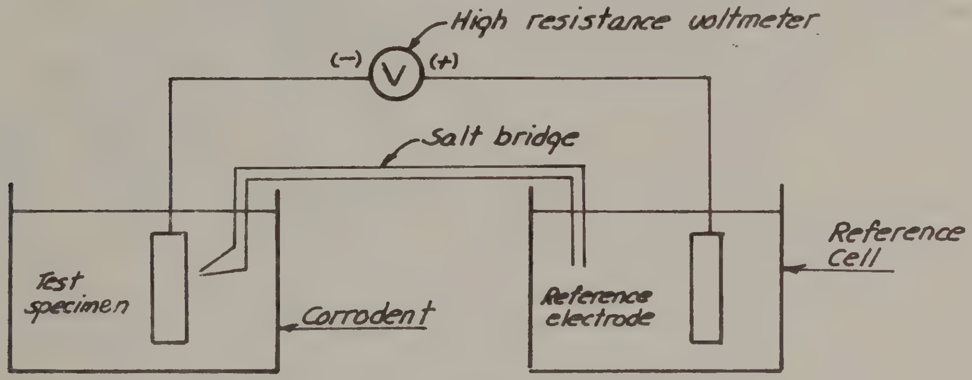



Figure A-2. Equipment to measure corrosion potential.

on the voltmeter would be the corrosion potential of the test specimen in the corrodent.

The hydrogen half-cell is not a convenient piece of equipment for most measurements because the reaction involves a gas. However, any pure metal which is in equilibrium with a saturated solution of its own metal ions has a constant potential relative to the hydrogen half-cell. Since the potential of such a cell is not zero, the voltage measured in Figure A-2 would not be the same. Rather than converting all readings back to the hydrogen reference, it is common practice to report the measured values relative to the reference cell being used.

Of many possible reference half-cells available, the most common one used for field work is the copper-copper sulfate half-cell. In this cell a pure copper rod is suspended in a saturated copper sulfate solution (see Figure A-3). As long as the solution remains saturated, no more copper ions can leave the surface of the rod without precipitating copper sulfate out of solution. Thus, the potential of the cell i.e. the electric force opposing the solvation of additional copper ions, is a constant +0.3160 volts at 77°F (25°C) relative to the hydrogen half-cell.

It should be noted that there are two recognized and opposite conventions for the sign of the half-cell potential. However, the most widely accepted convention and that used by the National Association of Corrosion Engineers, assigns positive values to more noble metals such as gold and copper, and negative values to more active metals such as iron and zinc relative to the

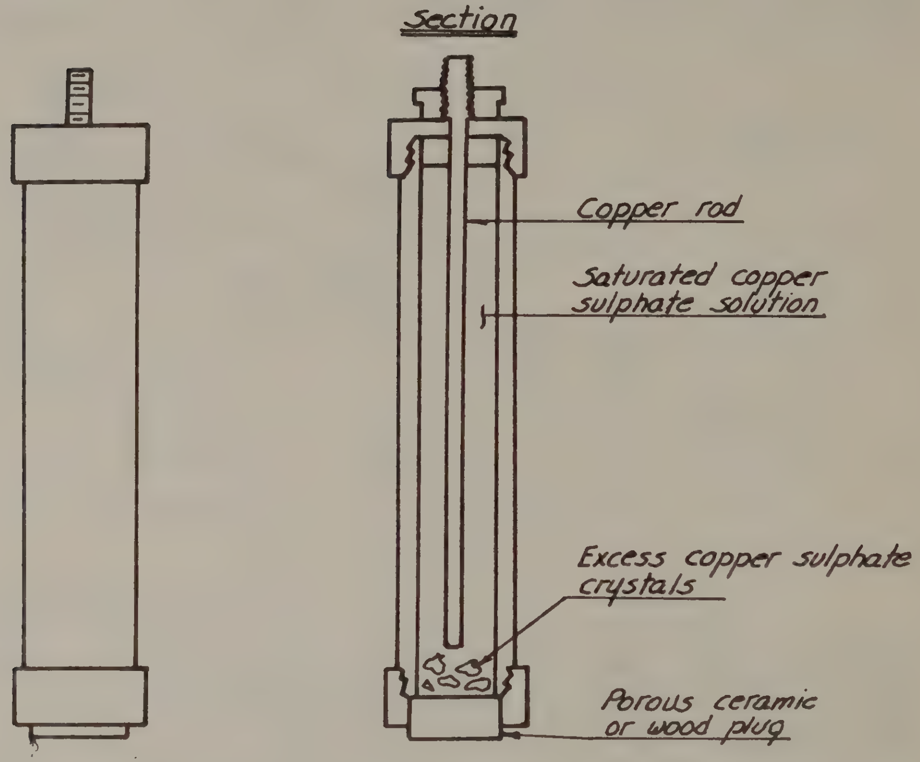



Figure A-3. Typical Copper-copper sulfate reference electrode.

standard hydrogen half-cell potential. Following this convention, the corrosion potential of steel is normally found to be more negative than the copper-copper sulfate half-cell potential.

The potential of the copper-copper sulfate half-cell varies with temperature, plus 0.0009 volts per degree Celsius increase (0.0005 volts per degree Fahrenheit). This variation is small enough that it can be ignored for measurements made with a half-cell in the range 19 to 31°C (67 to 87°F). For readings made with a half-cell at other temperatures, the reading must be increased for lower temperatures and decreased for higher temperatures. For example, if a measurement were made with a half-cell at 12°C, the reading on the voltmeter would be the algebraic difference between the half-cell potential and the corrosion potential,

$$(\text{Cu-CuSO}_4 \text{ Half-Cell Potential})-(\text{Corrosion Potential})=\text{Voltmeter Reading.}$$

Since the half-cell is at 12°C, the half-cell potential is not +0.316 volts, but is lower by a factor of 0.0009 volts per degree. It can be seen from the equation above that the reading on the voltmeter must be corrected by the same factor. Assuming the reading on the voltmeter was +0.362 volts, the corrected value would be found by the following equation

$$\text{Voltmeter Reading} + (25^{o}C - \text{Half-Cell Temperature})(0.0009V/^{o}C) = \text{Correct Reading.}$$

For the example given above

$$+0.362 + (25-12)(0.0009) = 0.362 + 0.0117 = +0.374 \text{ volts.}$$

In order to make the appropriate temperature correction to any field data, it is necessary to know the approximate average temperature of the half-cell during the period in which the measurements were made. For most purposes this can be assumed to be the average ambient air temperature at that location.

An additional variable in the use of the copper-copper sulfate half-cell is a phenomenon known as polarization. This occurs when a significant amount of current passes through the cell and causes a shift in the potential of the cell. Obviously a variation like this in the reference cell would certainly make the potential measurements questionable. However, this shift is only significant when a substantial current on the order of 1 milliampere flows through the cell. If a voltmeter or multimeter with a high internal resistance is used in the measurement, a current of only a few microamperes will flow in the circuit and there will be no significant polarization.

On the basis of work done by others, we can say with 90% statistical confidence, that areas of reinforcing steel with a measured corrosion potential equal to or greater than 0.35 volts more negative than the copper-copper sulfate half-cell are actively corroding. Areas with a corrosion potential equal to or less than 0.20 volts more negative are passive. Corrosion potentials between 0.20 and 0.35 volts more negative than the copper-copper sulfate half-cell represent an area of uncertainty due to the variability of the measurement process.

As previously noted, the corrosion potential of reinforcing steel is usually more negative than the copper-copper sulfate half-cell potential. However, due to the arrangement of the half-cell and voltmeter the value of the corrosion potential is read on the voltmeter as a positive number. The negative sign is implied in such readings although it is not reported. It is possible for the corrosion potential of the steel to be more positive than the copper-copper sulfate half-cell potential. In that case the difference would appear on the voltmeter as a negative number and should be reported as such.

## C. Corrosion Potential Measurement Equipment

The typical equipment configuration used to measure reinforcing steel corrosion potentials is shown in Figure A-4. There are four major elements in the equipment: the voltmeter, the copper-copper sulfate half-cell, the ground connection to the reinforcing steel, and the solution contact between the half-cell and the reinforcing steel. The role of each of these elements will be discussed briefly.

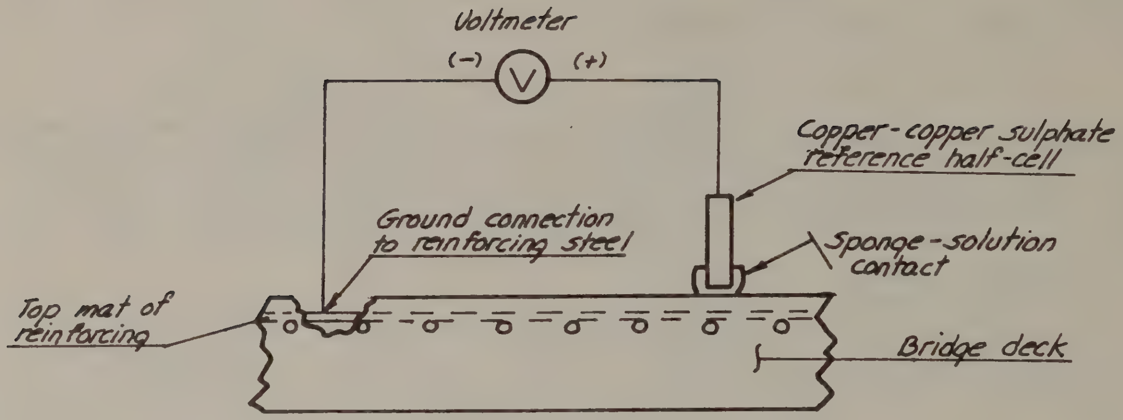



Figure A-4. Equipment used to measure reinforcing steel potential.

Voltmeter. The voltmeter measures the potential difference that exists between the reference half-cell and the reinforcing steel in the vicinity of the half-cell. It is used with the negative or ground terminal connected to the reinforcing steel and the positive terminal connected to the copper rod of the reference half-cell. In order to minimize the current flowing in the circuit, a high impedance voltmeter (100,000 ohms/volt or greater) should be used to prevent polarization of the reference half-cell.

Copper-Copper Sulfate Half-Cell. The half-cell provides the constant fixed potential reference necessary to measure the corrosion potential of the reinforcing steel.

Ground Connection to Reinforcing Steel. In order to measure the corrosion potential of the reinforcing steel, a good electrical contact (low resistance) between the negative side of the voltmeter and the top mat of reinforcing steel is necessary. Because of the numerous contacts between the reinforcing bars, a single electrical contact may be used for an entire slab span of the bridge. Since the reinforcing steel is not continuous over transverse joints, a separate ground must be established for each slab-span.

In the past it was thought that any ground connection which provided a continuous electrical path to the reinforcing steel was acceptable. Therefore such various grounds as anchor bolts, bridge rail, armored joints and steel girders were used. However the use of these indirect grounds based on their low electrical resistance ignored another important electrical effect, the coupling of dissimilar metals. When two dissimilar metals are coupled in an electrolyte, they may create an electric potential just as the electrodes on the surface of the reinforcing steel do. Unfortunately if this additional potential is included

in our measurement circuit, we no longer know what potential we are measuring. For this reason, we cannot use ground connections which rely on the contact between dissimilar metals such as galvanized bridge rail anchors or stainless steel anchor bolts. The only ground connection which can't introduce an additional unknown potential is a direct connection to the reinforcing steel.

Solution Contact. In order to measure the corrosion potential of the reinforcing steel a complete electrical circuit must exist. We can trace the circuit in Figure A-4 from the reinforcing steel through the voltmeter to the half-cell. At that point it is necessary to "connect" the copper sulfate solution in the half-cell to the reinforcing steel. The porous ceramic or wood plug in the half-cell is saturated with the copper sulfate solution but it may not be soft enough or large enough to make good contact with the bridge deck. For this reason a sponge wet with electrical contact solution (see below) is wrapped around the tip of the half-cell to improve the electrical contact and to reduce evaporation losses in the copper sulfate solution.

The concrete over the reinforcing steel is not a good electrical conductor. An electrical contact solution must sometime be used to wet the concrete in order to complete the electrical circuit. Such a solution is composed of a mixture of wetting agent or liquid household detergent thoroughly mixed with tap water in the ratio of 0.005:1 by volume. This would be 3.2 ounces (95 milliliters) of detergent per 5 gallons (19 liters) of water. Under working temperatures of less than 50°F (10°C), about 15% by volume (3 quarts or 2.8 liters) of either isopropyl or denatured alcohol must be added to the solution to prevent clouding. Clouding may inhibit penetration of the solution into the concrete.

The need for pre-wetting the concrete with the electrical contact solution can be determined by placing the half-cell on the concrete surface and observing the voltmeter to determine if the measured potential changes or fluctuates with time. A change greater than 0.01 volts in five minutes indicates that pre-wetting of the concrete surface is required. If the reading does not stabilize after pre-wetting, there may be excessive electrical resistance in the circuit which must be eliminated.

## D. Field Procedures

Environment. In general, there are few environmental restrictions on the measurement of corrosion potentials in bridge decks. As previously mentioned the temperature of the reference half-cell has only a minor effect on the measurements, therefore the only temperature limitation is 0°C (32°F) at which point the water contact between the half-cell and the reinforcing steel becomes inoperative. However, due to time lag between ambient temperature changes and deck temperature changes it is good practice to use 4°C (40°F) as the low temperature limit.

Potentials cannot be measured in the rain, on decks with standing water, or

on excessively wet decks because the electrical path through the water may extend a great distance from the half-cell location. For this reason the location and magnitude of the corrosion potential is uncertain. It is good practice to wait several hours after a rain to allow any excess moisture to escape from the deck before measurements are begun.

Equipment. Before any wiring connections are made the voltmeter should be checked to insure its batteries are charged (refer to the instruction manual supplied with the meter).

Next the copper-copper sulfate half-cell should be examined to see that it is filled with saturated copper sulfate solution. In order to insure that the solution remains saturated, excess copper sulfate crystals should always be maintained in the half-cell. Some half-cells have clear plastic sides where the crystals are visible. If the half-cell has lost solution it should be refilled using distilled or deionized water. Additional reagent grade copper sulfate crystals should then be added and the half-cell agitated until no more crystals dissolve. The half-cells are supplied with a rubber or plastic cap over the porous ceramic or wooden plug. This should be placed in position on the half-cell whenever it is not in use to minimize evaporation losses. A sponge wetted with electrical contact solution should be placed over the porous end of the half-cell when it is in use. Because the half-cell is temperature sensitive, it should be allowed to come to equilibrium with the ambient temperature before starting work.

Once the voltmeter and half-cell have been checked, the first wiring connection to be made is the ground connection to the reinforcing steel. The ground connection should be made halfway along the slab-span to maximize the deck area which can be reached without relocating. The ground connection must be made directly to an exposed reinforcing bar. In some instances "experimental" bridge decks already have electrical connections to the reinforcing bars and these should be used. If there are spalled areas where the reinforcing bar is sufficiently exposed to allow the placement of a clamp, the steel should be cleaned of all rust at the points where the clamp will contact the bar. Coarse emery cloth or a file should be used to clean the steel. When the surface of the bar has been cleaned, a C-clamp or battery clamp should be firmly affixed to the bar. If no reinforcing bars are sufficiently exposed to allow the placement of a clamp, use a roto-hammer to expose a bar and curl up a portion of the bar with a chisel. A clamp is then placed on the curled-up portion of the bar to make the ground connection.

The ohm scale of the multimeter should be used to determine the resistance of the ground connection by connecting the clamp to one side of the meter and using the test probe from the other side of the meter to contact the reinforcing bar adjacent to the clamp. The resistance should be less than 3 ohms, if not the steel may need more cleaning or the clamp may need to be adjusted to make better contact. The ground connection should also be checked by measuring the resistance between the ground and other exposed reinforcing bars, anchor bolts, armored joints, etc. Although one or two points may not show a low resistance, the majority of these points should be below 5 ohms. If the reinforcing bar chosen does not yield a low resistance ground

it may be electrically insulated from the top mat and another bar should be used.

When the ground has been established, the lead from the ground is connected to the negative or common input jack of the voltmeter. A ground connection can only be used for measurements on a single slab-span, i.e. between successive transverse joints.

Sufficient wire should be reeled off the cable reel to reach from the ground location to the farthest point on the slab-span. If the wire isn't long enough to reach the entire slab-span, additional grounds will have to be established to complete it. The reel end of the cable is then attached to the positive input jack of the voltmeter. The voltmeter should then be set on a scale capable of reading volts to the nearest hundreth of a volt. When using a digital voltmeter with three digits, this would be the ten volt scale. Finally, the other end of the wire is attached to the copper-copper sulfate half-cell.

Prior to making any measurements, the precision of the equipment should be checked. First a measurement should be taken at one location, the half-cell disconnected from the system and reconnected. The measurement is now repeated at the same location. If the two readings vary by more than 0.010 volts, the equipment is not functioning properly and should be checked. The second check for precision is to measure the potential at one location using two different half-cells. If the readings vary by more than 0.020 volts the equipment is not functioning properly. Failure to satisfy either of these checks may indicate a faulty half-cell, i.e. contaminated, un-saturated copper sulfate solution, etc. It might also indicate a faulty meter, ground connection or circuit. Once the cause of the error is located and corrected, the precision checks are repeated. When satisfactory results are obtained, potential measurements may be taken.

It was noted previously that dry concrete is not a good electrical conductor, therefore pre-wetting the concrete with electrical contact solution may be necessary if stable readings can't be obtained. The concrete may be wet by pouring a small amount of the electrical contact solution on the surface at each measurement location. Another method is to place sponges soaked in the solution at each location. The potential can then be measured by placing the half-cell on top of the sponge. Pre-wetting is satisfactory when the potential reading at a point is stable, i.e. it does not vary by more than 0.01 volts in five minutes. If stable readings cannot be obtained after pre-wetting, either the electrical resistance of the circuit is too great to obtain valid corrosion potentials, or stray current from a fluctuating direct current source such as an arc welder is affecting the readings. In either case the problem must be corrected before measurements may be taken.

Although the preceding material has attempted to cover all possible problems which might arise when making corrosion potential measurements, there may occur situations which were unforseen at the time this manual was prepared. Any unresolved problems or unusual results should be referred to the Field Services Section of the Materials Bureau at 457-5956 for assistance.

# APPENDIX B - BRIDGE DECK CONDITION

## SURVEY EQUIPMENT

Figures B-1, B-2, and B-3 show the basic equipment required to conduct a bridge deck condition survey. On the page opposite each figure is a detailed list of the equipment shown and a list of additional supplies or equipment necessary to perform the measurements.

## CORROSION POTENTIAL MEASUREMENT EQUIPMENT

1. Five gallon polyethylene jug for electrical contact solution.
2. One gallon polyethylene jug with faucet for electrical contact solution.
3. Liquid detergent for electrical contact solution.
4. Reagent grade copper sulfate crystals.
5. 2-Copper-copper sulfate half-cells, one with sponge on tip.
6. Water deionizer.
7. Highway Maintenance Subdivision's "Safety Manual".
8. High impedance volt-ohm meter (B&K Model 280 digital multimeter shown).
9. Tool box.
10. AC adaptor-charger for use with multimeter.
11. 100 foot cloth tape.
12. Hand tools (hammer, cold chisel, file, pliers, screwdrivers, emery cloth).
13. Celsius thermometer.
14. Spray paint.
15. 100 feet of wire connecting half-cell to volt-ohm meter.
16. Short leads and clamps for ground connections to reinforcing bars.

### Additional Equipment

Roto-hammer (see Figure B-3).
Pachometer (see Figure B-2).
BR-334 Bridge Deck Condition Survey forms.
Clipboard, pen, paper.
Alcohol for electrical contact solution.


Figure B-1. Corrosion potential measurement equipment.

## DEPTH OF COVER MEASUREMENT EQUIPMENT

1. Pachometer (Inspector Model Ferrometer by Intrafix, Inc. shown).
2. AC adaptor-charger for use with pachometer.
3. 5-Reinforcing bars for calibration.
4. Wood spacers for calibration.

### Additional Equipment

BR-334 Bridge Deck Condition Survey forms.
Clipboard, pen, paper.
Keel (lumber crayon).
Ruler.

## DELAMINATION DETECTION EQUIPMENT

5. Chain drag.

### Additional Equipment

Keel (lumber crayon).
BR-334 Bridge Deck Condition Survey forms or 1"=10' drawing.
Clipboard, pen, paper.

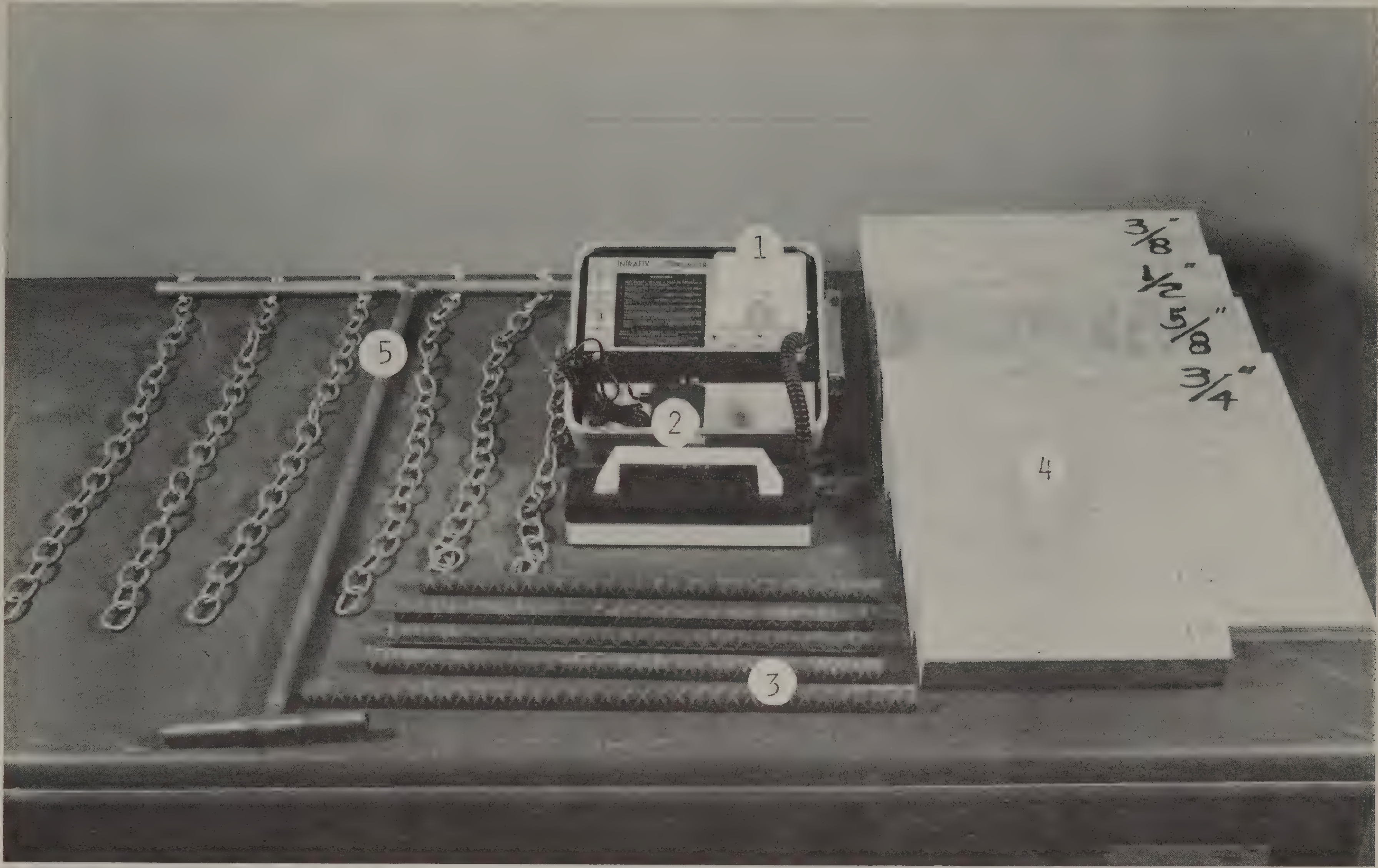



Figure B-2. Depth of cover measurement and delamination detection equipment.

## CHLORIDE ANALYSIS EQUIPMENT

1. Roto Hammer (Skil Model No. 728 shown).
2. Sample tubes with air tight caps (12x75mm culture tubes shown).
3. Rubber syringe.
4. Bull point.
5. 3/4" x 6" carbide drill bit.
6. Sample retrieval spoon.
7. Ruler.
8. Masking tape.

### Additional Equipment

110 Volt AC power source.
Permanent ink marking pen.
Clipboard, paper, pen.


Figure B-3. Chloride analysis equipment.

# APPENDIX C - SAMPLE COMPUTER MAPS

Figures C-1, C-2, C-3, and C-4 are examples of the maps produced by the SYMAP computer program from data submitted to the Materials Bureau. These figures show respectively depth of concrete cover (pachometer readings), corrosion potentials, and concrete removal maps for Class B and Class C removal. The exact locations of the pachometer and half-cell readings are represented by the decimal point of the values printed on the maps. The reading locations on the concrete removal maps are represented by the letter P. These points correspond to the data grid established on the deck by the survey crew.

On the full-size (11"x14") computer printout sheets, the maps are printed on a 1" = 10' scale. The figures shown here are approximately 75 percent reproductions. The particular slab-span shown is 28'x106' and therefore is small enough to be printed on one sheet. Larger slab-spans are printed on as many sheets as necessary. The Structures Design and Construction Subdivision should be contacted for specific instructions on incorporating this data in contract plans.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2.38 | 2.00 | 2.13 | 2.13 | 2.50 | 2.13 | 2.13 | 1.88 | 1.88 | 1.75 | 1.63 |
| 1.63 | 1.63 | 1.38 | 1.38 | 1.63 | 1.63 | 1.63 | 1.50 | 1.63 | 1.50 | 1.50 |
| 2.13 | 1.88 | 1.38 | 1.63 | 1.88 | 1.88 | 1.75 | 1.75 | 2.13 | 2.13 | 1.88 |
| 2.63 | 2.25 | 2.13 | 1.75 | 2.13 | 2.00 | 1.88 | 1.63 | 2.00 | 2.38 | 2.13 |
| 2.50 | 1.88 | 2.25 | 1.75 | 2.00 | 2.00 | 2.00 | 1.38 | 1.88 | 2.25 | 2.00 |
| 2.63 | 2.75 | 2.63 | 2.63 | 2.75 | 2.75 | 3.25 | 2.50 | 2.50 | 2.50 | 2.13 |

BIN 1054939 SLAB-SPAN NO. 24 W/B

SYMAP

PACHOMETER READINGS

Figure C-1. Sample Depth of Cover Computer Output

| | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.25 | 0.33 | 0.33 | 0.36 | 0.44 | 0.38 | 0.47 | 0.36 | 0.35 | 0.35 | 0.29 | 0.24 | 0.33 | 0.28 | 0.28 | 0.29 | 0.31 | 0.30 | 0.29 | 0.41 | 0.52 |
| 0.26 | 0.28 | 0.40 | 0.36 | 0.43 | 0.46 | 0.56 | 0.46 | 0.41 | 0.44 | 0.31 | 0.28 | 0.35 | 0.29 | 0.38 | 0.37 | 0.30 | 0.41 | 0.30 | 0.45 | 0.45 |
| 0.17 | 0.26 | 0.34 | 0.32 | 0.48 | 0.52 | 0.54 | 0.51 | 0.31 | 0.42 | 0.21 | 0.28 | 0.27 | 0.28 | 0.32 | 0.24 | 0.18 | 0.19 | 0.20 | 0.45 | 0.37 |
| 0.29 | 0.38 | 0.38 | 0.44 | 0.51 | 0.67 | 0.69 | 0.67 | 0.36 | 0.39 | 0.42 | 0.46 | 0.44 | 0.55 | 0.43 | 0.37 | 0.40 | 0.33 | 0.29 | 0.53 | 0.45 |
| 0.40 | 0.53 | 0.29 | 0.49 | 0.46 | 0.51 | 0.62 | 0.58 | 0.52 | 0.53 | 0.42 | 0.47 | 0.46 | 0.43 | 0.44 | 0.55 | 0.41 | 0.36 | 0.29 | 0.47 | 0.44 |
| 0.29 | 0.28 | 0.25 | 0.31 | 0.33 | 0.37 | 0.41 | 0.35 | 0.31 | 0.24 | 0.25 | 0.20 | 0.20 | 0.21 | 0.16 | 0.19 | 0.18 | 0.18 | 0.10 | 0.23 | 0.37 |

BIN 1054939 SLAB-SPAN NO. 24 W/B

SYMAP

Figure C-2. Sample Corrosion Potential Computer Output

HALF-CELL POTENTIAL READINGS

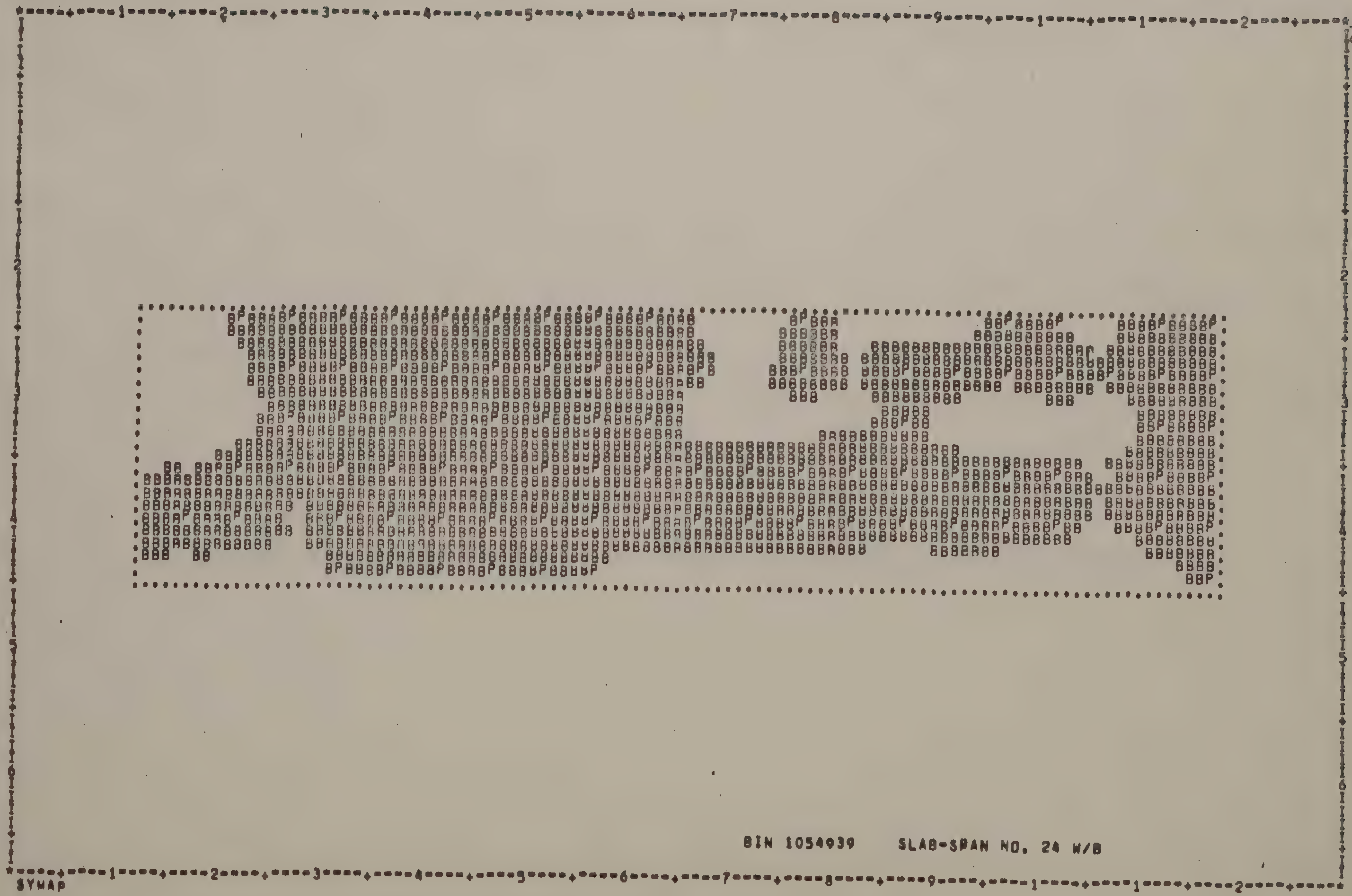



Figure C-3. Sample Concrete Removal Map - Class B

WORK ITEM -- CLASS B = POTENTIALS GREATER THAN OR EQUAL TO 0.30

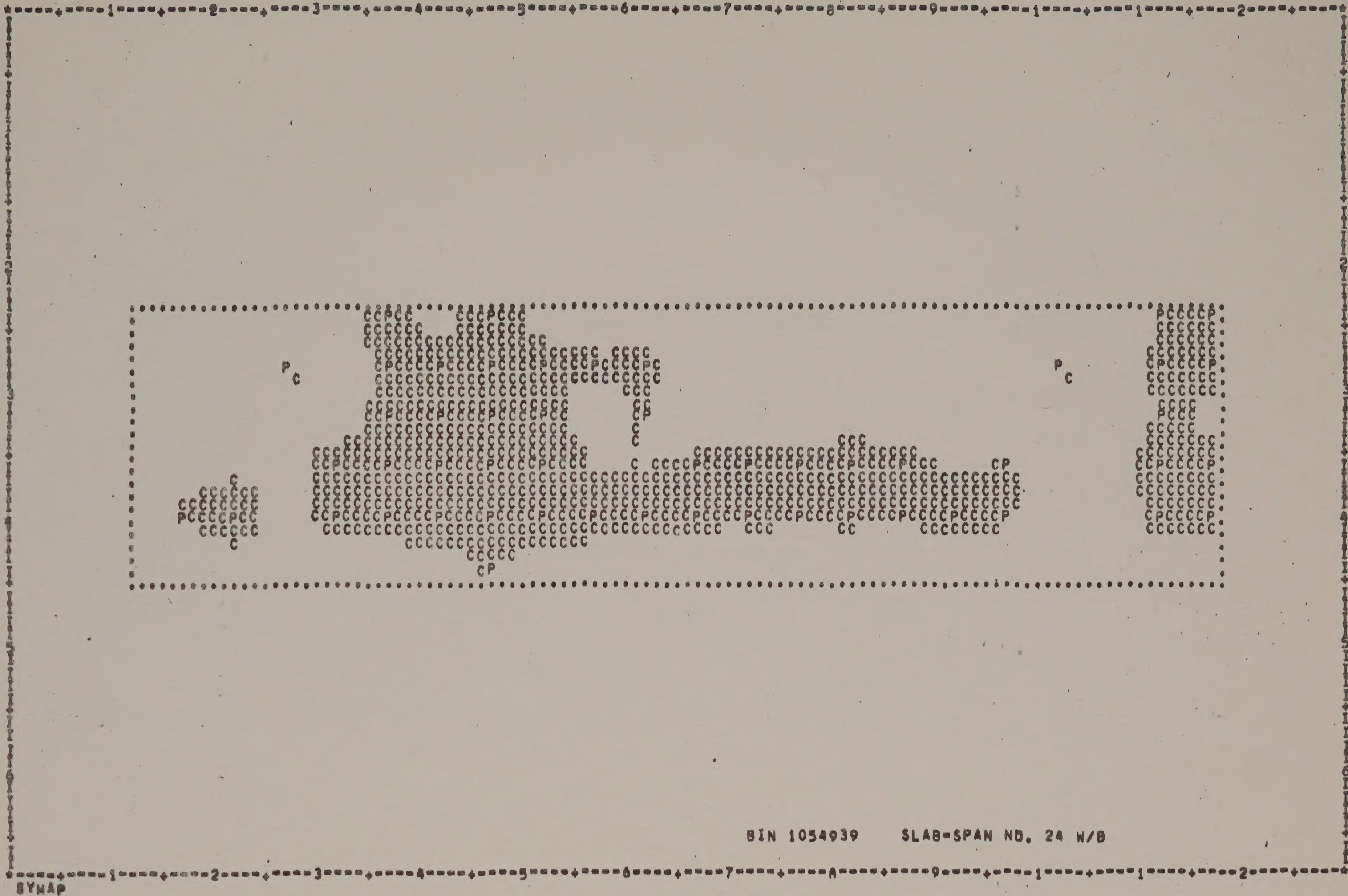



Figure C-4. Sample Concrete Removal Map - Class C

WORK ITEM -- CLASS C = POTENTIALS GREATER THAN OR EQUAL TO 0.40